AVIATION OCCURRENCE REPORT
A97C0236

COLLISION WITH TERRAIN

SOWIND AIR LIMITED
EMBRAER EMB-110P1 BANDEIRANTE C-GVRO
LITTLE GRAND RAPIDS, MANITOBA
09 DECEMBER 1997

Transportation Safety Board
of Canada

Bureau de la scurit des transports

du Canada

Aviation Occurrence Report

Collision with Terrain

Sowind Air Limited
Embraer EMB-110P1 Bandeirante C-GVRO
Little Grand Rapids, Manitoba
09 December 1997

Report Number A97C0236

Synopsis

The Sowind Air Ltd. Embraer EMB-110P1 Bandeirante aircraft departed the operator's base at St. Andrews, Manitoba, with a crew of 2 and 15 passengers, on a 40-minute, scheduled flight to Little Grand Rapids, Manitoba. The aircraft arrived at Little Grand Rapids, and the crew flew an instrument approach to the airport and executed a missed approach because the required visual reference was not established. A second instrument approach was attempted. Ground-based witnesses observed the aircraft very low over the lake to the south of the airport and to the east of the normal approach path. Passengers in the aircraft also reported being very low over the lake and to the east of the normal approach path. The passengers described an increase in engine power followed by a rapid series of steep banking manoeuvres after the aircraft crossed the shoreline to the southeast of the airport. During the manoeuvres, the aircraft descended into the trees and crashed approximately 400 feet south and 1 600 feet east of the approach to runway 36 at Little Grand Rapids. The captain and three passengers were fatally injured, and the first officer and the remaining 12 passengers were seriously injured.

Ce rapport est également disponible en français.

1.0 Factual Information

1.1 History of the Flight

The Sowind Air Ltd. Embraer EMB-110P1 Bandeirante aircraft, Flight 301, departed St. Andrews, Manitoba, at 1415 central standard time on a 40-minute, scheduled flight to Little Grand Rapids, Manitoba.[1] Onboard the aircraft were a crew of 2 and 15 passengers. The flight was pilot self-dispatched and departed under visual flight rules (VFR) in controlled airspace. When the aircraft approached Little Grand Rapids, the crew received the unofficial airport weather report by radio from the airport manager (APM). The weather was reported as a ceiling of 200 feet above ground level (agl)[2] and a visibility of one statute mile,[3] and the crew flew an instrument approach. When the aircraft was overhead the airfield, the crew asked the APM if the aircraft could be seen. The APM responded negatively and the crew initiated a missed approach advising that they had not acquired the airport visually.

After the aircraft had climbed back above the cloud layer, a second Sowind Air Ltd. aircraft, a PA31-350 Navajo, Flight 318, arrived in the vicinity of Little Grand Rapids, operating under VFR. The Navajo pilot reported that he flew over the airport from the southwest at a height of about 300 feet agl, turned, and made a successful landing on runway 18. He then advised the Bandeirante crew by radio that the visibility on final for runway 18 was two miles and that he was on the ground. The Navajo was clearly seen, by witnesses, over the lake to the south of the runway. The approach flown by the Navajo was described as west of the normal approach path to runway 36, but conforming to about the altitude usually observed.[4] The Navajo was observed flying over the runway at low level before turning for an approach to runway 18. One witness described the Navajo as appearing as a vague outline; another observer stated that the Navajo appeared to "pop out" over the runway.

Based on the information gathered during the investigation, including that from witnesses and survivors, the following scenario was derived. The Bandeirante crew then began a second approach from above the cloud layer. The aircraft approached from the south over the community of Little Grand Rapids, to the east of the flight path of the Navajo, and crossed the lake at low level. The aircraft was at about half the height flown by the Navajo or about 150 feet above the lake surface. When the aircraft approached the shoreline to the southeast of the airport, the engine power was advanced. The aircraft then banked quickly left and then right and disappeared from view in fog as it descended. The track followed by the aircraft was east of the normal approach path and at low level. Power was applied just before the aircraft banked rapidly to the left, followed

---

1 All times are central standard time (coordinated universal time minus six hours) unless otherwise stated.

2 See Appendix E - Glossary for all abbreviations and acronyms.

3 Units are consistent with official manuals, documents, reports, and instructions used by or issued to the crew.

4 See Appendix A - Approach Outlines.

by a nearly immediate right bank and impact with the terrain. The aircraft descended into the trees in a shallow left bank approximately 400 feet south and 1 600 feet to the east of the approach to runway 36. During the banking manoeuvres, the aircraft passed in proximity to an abandoned, 93-foot fire tower. The aircraft crashed at 1526, in daylight hours, at latitude 52°02' N, longitude 095°53' W, at an elevation of 1 050 feet above sea level (asl).

1.2 Injuries to Persons

	Crew	Passengers	Others	Total
Fatal	1	3	-	4
Serious	1	12	-	13
Minor/None	-	-	-	-
Total	2	15	-	17

The captain and three passengers were fatally injured. The first officer and the other 12 passengers suffered varying degrees of serious injuries. The first officer's injuries were such that he was unable to provide any statement to the Board.

1.3 Damage to Aircraft

The aircraft was destroyed by the impact forces.

1.4 Other Damage

There were trees damaged, and the fuel that was on board the aircraft spilled onto the ground.

1.5 Personnel Information

1.5.1 General

	Captain	First Officer
Age	62	30
Pilot Licence	Airline Transport	Commercial
Medical Expiry Date	01 June 1998	01 March 1998
Total Flying Hours	15 000	700
Hours on Type	114	367
Hours Last 90 Days	73	135
Hours on Type Last 90 Days	73	135
Hours on Duty Prior to Occurrence	8	3
Hours Off Duty Prior to Work Period	14	18

1.5.2 The Captain

1.5.2.1 General

The captain had successfully completed a pilot proficiency check (PPC) and instrument flight check (IFC) on the Bandeirante on 03 February 1997, and held a Group 1 instrument rating. The captain's medical certificate was current, with a requirement that glasses be available.

The captain began his employment with Sowind Air Ltd. in February 1997 and left the company in April 1997. He flew the Curtis Wright C-46 for another company and then returned to Sowind Air Ltd. in October 1997. At the time of the occurrence, the captain was the chief pilot for Sowind Air Ltd. He was appointed to that position on 03 December 1997 and was responsible for standard operating procedures, training programs, operational suitability of aerodromes and routes, and the supervision of flight crews.

Information revealed conflicts between the captain and other company Bandeirante pilots, to the extent that several did not like to fly with him. The occurrence first officer had on one occasion formally expressed this dislike; however, there was some information that indicated that the first officer had adjusted and accepted the captain's methods. The conflicts surfaced because of the captain's preference to fly VFR rather than instrument flight rules (IFR) and his tendency to continue VFR flight in marginal weather.

1.5.2.2 Flying History

The captain's records indicate that he had experienced no difficulty within the last five years with VFR flying skills on the Curtis Wright C-46 or the initial PPC and IFC on the Bandeirante. The Transport Canada (TC) inspector noted on the test report for the Bandeirante PPC, "Well flown initial PPC." Similar remarks were contained in other recent PPCs. The only difficulties that he had had with IFR flying skills within the last five years were noted on two IFC rides. On an IFC ride in February 1996, on the Curtis Wright C-46, the inspector marked a precision approach as satisfactory with briefing because of glide slope and localizer deviations. Similarly, on a PPC/IFC for the DC3 in February 1996, the inspector marked a holding as satisfactory with briefing because of an error in tracking to the fix.

The captain's records indicate that he had been involved in two aviation occurrences in the last 10 years that had been investigated by the TSB. Occurrence A90C0037 involved the near loss of control of an HS-748 after full flap selection on approach. One of the findings of the report was that the captain had not calculated the centre of gravity of the aircraft before departure, and the cause was as follows: "A centre of gravity beyond the aft limit combined with the application of full flaps resulted in an uncontrollable nose-up pitching moment and a near loss of control during the initial landing attempt." Occurrence A93C0113 also involved an HS-748. It was determined that the cause of this accident was, "The pilot continued with an unstabilized approach and landed with insufficient runway remaining to stop the aircraft within the confines of the published runway length." One of the findings of the report was that, "The aircraft crossed the threshold of the runway at an airspeed of approximately 130 knots. The maximum threshold speed for an aircraft weight of 42,000 pounds is 110 knots." The captain's records beyond 10 years indicate some variability of performance. He failed two IFCs, in June 1986 and April 1985. He failed one PPC in May 1988. Several test reports had adverse comments with respect to instrument procedures and others had comments such as "A smooth and experienced captain."

1.5.3 The First Officer

1.5.3.1 General

Company pilots described the first officer as requiring extra assistance on occasion. For example, he had experienced difficulty initially understanding and using the global positioning system (GPS). He was reportedly one of several pilots who programmed the runway thresholds into the GPS as waypoints and used these waypoints during approaches in both IFR and VFR conditions. He was described as an individual who spoke up if he believed flying safety was compromised.

1.5.3.2 Flying History

The first officer began flight training in 1993 to secure a commercial licence. He passed a commercial flight test in March 1996, obtained an instrument rating in May 1996, and a flying instructor rating in December 1996. He was hired by Sowind Air Ltd. in the spring of 1997. After completing company training, he failed his initial PPC/IFC on the Bandeirante in April 1997, and his instrument rating was suspended. He failed the second PPC/IFC attempt on 02 May 1997. On May 15 he passed the third attempt. The first officer had a current medical certificate and had completed a pilot decision-making course conducted by TC on 04 October 1997.

1.6 Aircraft Information

1.6.1 Aircraft Data

Manufacturer	Embraer (Empresa Brasileira de Aeronautica)
Type and model	EMB-110P1
Year of manufacture	1980
Serial number	110285
Certificate of Airworthiness (Flight permit)	Yes
Total airframe time	13 724 hours
Engine type (number of)	Pratt & Whitney PT6A-34 (2)
Propeller/rotor type (number of)	Hartzell HC-B3TN-3C (2)
Maximum allowable take-off weight	12 500 lb
Recommended fuel types	JP-4, JP-5, Jet A, Jet A-1, Jet B
Fuel type used	Jet B

1.6.2 Aircraft Description

The Embraer Bandeirante is a low-wing, twin-turboprop, non-pressurized monoplane with an all-metal stressed skin structure, cantilever wings and empennage, and a semi-monocoque structural fuselage. The landing gear is a single wheel, hydraulically operated, retractable tricycle type. The flight controls are operated by a cable and pulley system that is connected to bell cranks and push/pull rods in the wings and tail. The aircraft is equipped with two over-wing emergency exits, a large rear hydraulically operated cargo door, a forward passenger door on the left side of the fuselage, and a forward emergency exit crew door on the right side of the fuselage. The aircraft is equipped with pneumatically operated leading edge de-icer boots, electrically operated propeller de-icer boots, electric blankets for the engine air inlets, an electrically heated centre windshield with wiper blades, and an engine bleed air defrost system. The aircraft is type-approved to operate in Canada and is

designed to carry 19 passengers and
2 crew members.

The occurrence aircraft was imported from the United States in July 1996, and underwent extensive inspection and refurbishment before the issuance of a Canadian Certificate of Airworthiness on 09 December 1996. The aircraft was flown approximately 1 150 hours during its one year of operation with the company. The most recent major work performed on the aircraft was a hot section inspection of both engines, completed on 01 December 1997, eight days before the accident. At the time of the accident, there were no recorded deferred maintenance items or unserviceabilities with the aircraft. The aircraft was being maintained on a progressive inspection program with inspection checks due every 75 hours. The last inspection of the aircraft was an A1 & A2 check conducted on 07 November 1997 at an airframe time of 13 674.4 hours. The aircraft was due for a major C12 or 1200-hour inspection in approximately 50 hours' time.

1.6.3 Weight and Balance Information

The aircraft is approved to operate at a maximum take-off weight of 12 500 pounds, with a maximum landing weight of 12 015 pounds. The aircraft's maximum ramp weight, accounting for fuel burn prior to take-off, is 12 566 pounds. At weights above 8 818 pounds, the aircraft's C of G limits are between 255.5 inches and 272.0 inches aft of the datum or 9.5 per cent to 31 per cent mean aerodynamic chord (MAC). At weights below 8 818 pounds, the C of G limits are between 251.3 inches and 272.0 inches aft of the datum or 4 per cent to 31 per cent MAC with a straight line variation between the points.

With the extensive refurbishment of the aircraft during the certificate of airworthiness approval process, which included new upholstery and paint, the company decided to reweigh the aircraft. The aircraft was weighed on 20 November 1996 by Sowind Air Ltd. The aircraft was weighed in the cargo configuration with full hydraulic system fluid and residual fuel and oil. A new weight and balance report was produced, which was submitted to TC along with a revised equipment list.

The weight and balance report was prepared by and signed by the maintenance coordinator of Sowind Air Ltd. The maintenance coordinator did not hold the appropriate endorsement on his licence for the aircraft type and, therefore, did not have the authority to sign the weight and balance report. The weight and balance report contained numerous errors, including incorrect scale weights, incorrect moment calculations, and incorrect empty weight C of G calculations. These are included in the discrepancies listed in Appendix C. The equipment list had not been fully updated and several items were shown as being installed on the aeroplane, when in fact the items had been removed before the weighing of the aircraft. As well, several items, such as a

KR87 ADF installation, a new and lighter aircraft battery, the survival gear, and cargo net installation were not added to the equipment list to show that they had been installed on the aircraft.

1.6.4 Equipped Operating Weight

The equipped operating weight (EOW) is the weight of the aircraft ready for flight, including crew, but excluding fuel, passengers, and baggage. The company computed an EOW of 7 971 pounds. To derive this calculation, the company took the empty weight of the aircraft of 7 607 pounds and added two crew, using a summer weight of 182 pounds per crew member. No allowance was made for the weights of unusable fuel, engine oil, crew baggage, aircraft flight manuals, survival gear, the cargo net and strap installation, or the seasonal allowance for the winter weights of the flight crew; the sum of these weights was approximately 200 pounds. This additional weight was not included in the weight calculations for the aircraft.

1.6.5 Aircraft Seating Configuration and Loading Graphs

The aircraft was originally configured by the operator to carry 15 passengers. The seats were spaced to provide maximum leg room and comfort for the passengers, and the company produced a sample weight and balance loading graph using the revised 15-passenger seat location. However, the C of G location on the loading graph was in error as a result of the mistakes made in the basic weight and balance document.

At some point during the year that the aircraft had been operated by the company, the aircraft seating configuration was changed to provide seating for 18 passengers. The 15 seats were placed closer together to allow for the placement of an additional row of 3 seats. The last row of seats was removed or installed depending on load requirements. When removed, the area was used for cargo. No weight and balance adjustments were made by the company for the new seating or cargo configuration, nor could the company provide sample weight and balance loading graphs to cover the full range of aircraft loading possibilities.

1.6.6 Cancelled Morning Flight Load Calculations

On the morning of the occurrence, the aircraft had been scheduled to fly to Little Grand Rapids with a load consisting of eight passengers and 1 166 pounds of freight. Because the passenger load was less than nine passengers, single pilot operation was authorized, and the occurrence captain was scheduled to fly the aircraft. The freight consisted of 1 144 pounds of food goods destined for Little Grand Rapids and 22 pounds of freight destined for Paungassi, Manitoba. The freight was loaded onto the aircraft by the company operations manager and the occurrence aircraft captain. The occurrence aircraft captain fuelled the aircraft and entered into the fuel log an upload of 450 litres of Jet-B aviation fuel. The total fuel load on the flight load

manifest was recorded as 1 400 pounds. The all-up weight (AUW) on the flight load manifest was estimated at 12 477 pounds. The front office manager arranged for the aircraft load for the morning flight.

The flight was put on hold because of poor weather in the Little Grand Rapids area, and the company decided to cancel the flight and wait for an improvement in the weather for the afternoon flight. Some of the passengers decided not to wait for the afternoon flight, and the company shipping manager drove those passengers and their luggage into Winnipeg. When the shipping manager returned, the afternoon flight had departed.

1.6.7 Occurrence Flight Load Calculations

The company was expecting a higher passenger load for the afternoon flight and a second pilot had been called in to act as first officer on the Bandeirante. A customer support clerk arrived for her shift after the morning flight had been cancelled and arranged the aircraft load for the afternoon flight. The front office manager was away from the office when the customer support clerk arranged for the load, and the clerk did not know that the aircraft had already been loaded with cargo for the morning flight. The customer support clerk booked 15 passengers onto the flight and weighed their baggage at 295 pounds.

In the early afternoon, reports of an improvement in the weather were received from company staff at Little Grand Rapids and all flights were dispatched. The operations manager indicated to the pilot of the Bandeirante that he and his first officer would have to unload the freight from the aircraft by themselves, as he was busy with his own flight and the shipping manager was away. The customer support clerk gave the pilot the passenger load and baggage information, and the pilot asked if there was any room for additional cargo. The pilot indicated that he now had a fuel load of 1 600 pounds[5] and the clerk forecast the aircraft's total weight at 12 352 pounds. The pilot indicated that he would load an additional 150 pounds of cargo. The flight load manifest was amended to read an AUW of 12 500 pounds.[6]

1.6.8 Aircraft Overload

Calculations of the weight and balance for the occurrence flight are contained in Appendix B. The weight of the aircraft was calculated to have been between 13 230 and 13 830 pounds, exceeding the maximum take-off weight limit of 12 500 pounds by 730 pounds to 1 330 pounds. At impact, the aircraft was 495 to 1 095 pounds heavier than its maximum landing weight.

5 No record of a fuel upload could be found.

6 See Appendix B for a weight and balance calculation for the occurrence flight.

The estimate of 730 pounds overweight is based on the following: 200 pounds of unrecorded aircraft equipment, 42 pounds of unrecorded passenger weight, a flight load manifest calculation error of 2 pounds, 64 pounds of extra baggage located at the accident site, and 424 pounds of extra cargo (from the cancelled early morning flight) that was located at the accident site. The estimate of 1 330 pounds overweight is based on the preceding 730 pounds plus an additional 200 pounds of cargo from the early morning flight that could not be accounted for by the company or located at the occurrence site, and 400 pounds of extra fuel based on fuel quantity gauge readings derived after the occurrence.

1.6.9 Aircraft Approach and Stall Speeds

Figure 5-4 in the approved flight manual presents the stall speeds as a function of gear and flap configuration, and aeroplane weight and bank angle. Interpolation of the table gives an increase in the stall speed of from 2 to 3 knots indicated airspeed (KIAS) for a weight increase of 500 pounds for all configurations and bank angles. There are no data available for weights in excess of 12 500 pounds. At 12 500 pounds, the maximum take-off weight, and configured with landing gear down and flaps set at 25 per cent, the stall speeds are as shown in Figure 1.

Degrees of bank	Stall (KIAS)
0	85
30	91
45	101
60	121

The flight profile chart for non-precision approaches in the Sowind Air Ltd. Standard Operating Procedure (SOP) manual gives a non-precision approach speed of 120 KIAS for Sowind Air Ltd. Flight 301's aircraft configuration and position on the approach. Figure 5-26 in the approved flight manual gives a final approach speed of 112 KIAS for an aircraft weight of 12 500 pounds with flaps set at 25 per cent. The approved flight manual indicates that both the maximum
gear-lowering speed and maximum gear-extended speed are 145 knots.

1.6.10 Ground Proximity Warning System

A ground proximity warning system (GPWS) is designed to issue visual and aural warnings to the flight crew when their aircraft is too close to terrain or when the aircraft's terrain closure rate, rate of descent, or glideslope deviation becomes excessive. The warnings are based on GPWS internal logic, radar altimeter information, and the aircraft's configuration. GPWS has prevented many accidents where, until the warning sounded, the pilots had been unaware that the aircraft was in danger because of proximity to the ground or water. The occurrence aircraft was not equipped with a GPWS and none was required by the regulations.

1.7 Meteorological Information

South and central Manitoba had been under a stagnant flow and weather pattern for several days before the accident as a quasi-stationary high-pressure ridge dominated the province. The surface and low-level wind was weak and variable. The boundary layer of the atmosphere had been nearly saturated for several days with very few breaks in an extensive stratus cloud deck. On the morning of the accident, the lower level of the atmosphere consisted of an isothermal temperature layer with an inversion above. The airmass was nearly saturated throughout the isothermal layer. These elements combined to produce widespread areas of low cloud, fog patches, and patchy freezing drizzle. Typically, ceilings and visibilities were at their lowest at sunrise each day with marginal improvement through the afternoons.

Between Winnipeg and Little Grand Rapids, official Environment Canada weather observations of ceiling, visibility, and precipitation (including icing) are available from Winnipeg and Berens River, about 75 nautical miles from Little Grand Rapids. Visibility and precipitation reports are also available from Gimli, about 115 nautical miles southwest of Little Grand Rapids.

At the time of the aircraft's departure from the St. Andrews airport, the Winnipeg weather was reported as: ceiling partially obscured, a scattered cloud layer at 1 000 feet agl, an estimated ceiling of 2 500 feet agl overcast, and visibility three statute miles in light snow. At the time of the flight, the automated weather observation station at Gimli reported visibilities above nine statute miles with light easterly winds. The Berens River reports during the time period of the flight gave ceilings of 800 feet agl broken, 1 500 feet agl overcast with visibility of 15 statute miles in light snow.

Unofficial weather observations are available three times daily, at 0800, 1000, and 1500, from Little Grand Rapids and Bloodvein River, about 65 nautical miles west of Little Grand Rapids. Observations at these two sites are made by airport personnel employed by the Province of Manitoba and are available in the form of a special bulletin. Typically, the unofficial reports contain an estimate of ceiling height, visibility, and precipitation.

At 1500, the Bloodvein reported weather was a ceiling at 1 000 feet agl, with a visibility of three statute miles. The Little Grand Rapids reported weather was a ceiling of 200 feet agl with a visibility of one statute mile in fog.

Little Grand Rapids is in the extreme southern portion of the FACN32 forecast area, and just north of the region covered by the FACN31 forecast area. The area forecasts valid at the time of the accident were issued at 1130. Both forecasts indicated that a ridge of high pressure would lie east of the flight track giving a light variable flow to southern Manitoba. The airmass was forecast to be stable with extensive low-level moisture. En route, the FACN31 forecast called for general ceilings at 2 000 feet asl with tops at 4 000 feet asl. In addition, frequent stratus ceilings, between 400 and 1 200 feet agl, and isolated visibilities between one and five statute miles in snow, freezing drizzle and fog, were forecast; these lower conditions were expected to be more common over higher terrain. Moderate mixed icing was forecast in freezing drizzle with light rime icing elsewhere. The FACN32 forecast, which would form the basis for the terminal weather forecast at Little Grand

Rapids, called for slightly deeper cloud (tops at 5 000 feet asl) with a few stratus ceilings to 500 feet agl and visibilities to one statute mile in freezing drizzle and fog.

In general, the area forecasts were representative of the conditions reported. However, at Little Grand Rapids, the cloud ceiling reported by the observer was lower than the lowest forecast in the FACN32 forecast. This observation was made several hours after the release of the forecast; the lowest ceilings reported up to that point were well within the range of the forecast. Visibility observations were within the range of the forecast at the time of the accident. Additionally, the FACN32 forecast was more pessimistic concerning the extent of cloud ceilings in the area west of the ridge: many stations reported clear skies while the forecast called for broken to overcast conditions.

Pilot reports of the weather at the time of the accident were available from two sources, a local pilot who had taken off and returned because of weather about 50 minutes before the crash, and the pilot of the Sowind Air Ltd. Navajo who landed about 10 minutes before the accident. The local pilot reported that the ceiling was indefinite and varying between 100 and 200 feet agl, and that the visibility was one statute mile with fog down to the trees to the east of the runway and down to the water over the river immediately west of the runway. He reported his observations to the APM who, in conjunction with her own observation of the weather, reported the unofficial weather as 200 feet agl and one mile visibility. The Navajo pilot reported that he had one-mile visibility approaching from the south over the lake with a ceiling at 300 feet agl. He found that the visibility was two miles after he turned final for runway 18 to the northeast. He stated that the cloud base was ragged and that there had been patchy fog in the vicinity of his turn to runway 18.

During the day of the flight, the company president telephoned a relative in Little Grand Rapids for weather information. The information received indicated better ceilings and visibilities than those reported from the airport because the relative was located in the local community, further from the open water. Based on this weather information, the company president had his personal aircraft readied for a flight to Little Grand Rapids.

1.8 Aids to Navigation

A non-directional beacon (NDB), identifier 4B, is located on the Little Grand Rapids airport property, north of the centre point of the runway, and serves as an aid for a cloud-breaking procedure.

Sowind Air Ltd. has authorization from TC to use the NDB A approach at Little Grand Rapids. The chart is labelled "Company Use Only," and is not for public use without TC approval. The minimum descent height for the circling approach is 1 560 feet asl, 555 feet above the airport reference elevation. The procedure turn is flown to the southeast of the airport at a minimum altitude of 2 500 feet asl.

1.9 Communications

Communications between Sowind Air Ltd. Flight 301 and air traffic services were normal throughout the flight. The Sowind Air Ltd. Flight 301 transponder code of 1200 was recorded by the radar system until the flight left radar coverage about 55 nautical miles northeast of St. Andrews. On arrival in the area of Little Grand Rapids, Sowind Air Ltd. Flight 301 communicated with the APM using the aerodrome traffic frequency, and with the other company aircraft on the company frequency. With the exception of the radio transmissions between Sowind Air Ltd. Flight 301 and St. Andrews Tower and Winnipeg Terminal, no other radio transmissions were recorded.

1.10 Aerodrome Information

The aerodrome serving the community of Little Grand Rapids, a community of about 900 people, is a certified airport operated and maintained by the Government of Manitoba. The airport is identified as CZGR, and the airport reference elevation is 1 005 feet asl. It has one runway, 18/36, which is gravel-surfaced, 2 800 feet long and 75 feet wide.

Low-intensity runway threshold and end lights are available for both runways, and can be activated by aircraft radio control of aerodrome lighting (ARCAL). The lights are activated for 15 minutes by keying a microphone five times in five seconds on frequency 122.8 megahertz (MHz). There was no information to indicate whether the lights had been activated by the crew of the occurrence aircraft.

Runway 36 heads away from the main community and terminates at the shore of a rapids, which is open year round. Runway 18 heads towards a lake and has a 0.7 per cent slope up, terminating in a sharp drop-off to the lake shore. A river flows immediately to the north and west of the runway, and is also open year round. The terrain to the east of the airport is higher, heavily forested, and is about 70 feet above the surface of the lake. There is an abandoned, unpainted, and unlighted fire tower, about 93 feet in height, approximately 1 100 feet to the east of the threshold of runway 36. Trees in the area are about 50 to 70 feet in height.

1.11 Flight Recorders

The aircraft had been equipped with a Loral Fairchild cockpit voice recorder (CVR) before its importation from the United States. While in the United States, the aircraft had been taken out of service and the voice recorder was removed. The voice recorder control panel was removed during the importation of the aircraft; however, the mounting tray and wiring installation remained in the aircraft.

The aircraft was not equipped with a flight data recorder (FDR) nor was one required by the regulations.

1.12 Wreckage and Impact Information

1.12.1 General

The aircraft struck the tops of 40- to 50-foot trees in a near wings-level, slightly nose-high attitude, on a heading of 358 degrees magnetic. The aircraft's ventral fin and left elevator balance weight were torn off. The aircraft's left wing then struck trees tearing off six feet of the outboard section of the wing and aileron. The aircraft entered a roll to the left, arcing to a final heading of 344 degrees magnetic and began a 30-degree angle descent to the ground. The aircraft struck the ground in a steep left-wing-low, nose-down attitude and cartwheeled over the left wing, coming to rest upright and pointing back towards the initial impact point. The aircraft travelled approximately 435 feet from the initial tree contact to its final resting point. The aircraft was covered in trees that were torn down during the accident sequence, and the only portion of wreckage that was visible from the air was the aft fuselage structure. Until the arrival of the investigation team, the temperature remained below freezing and the aircraft was under both cloud cover and tree canopy.

The forward portion of the aircraft, including the cockpit and first two rows of passenger seats, up to the leading edge of the wings, was destroyed by impact forces. The main cabin structure, aft of the leading edge of the wings, remained largely intact, and the cargo in the aft cabin area remained secure beneath the cargo net. The horizontal stabilizer was torn from its mounting structure. The left engine and propeller were torn from their mounts and thrown backwards onto the left wing. The right engine remained within its mounts; however, the propeller separated at the reduction gear box and spun into the cockpit structure.

1.12.2 Landing Gear

Witnesses on the ground reported that the landing gear appeared to be extended before the accident. An examination of the wreckage found that the nose gear was broken and pushed forward; the right gear was partially folded underneath the wing, and the left gear was down and locked in position. The landing gear selector handle was bent and in the UP position; however, it could not be determined if it had been driven up during the impact. The emergency gear selector was found in the normal position. An examination of the landing gear indicator lamps by the TSB Engineering Branch Laboratory (LP 193/97) showed that the green "gear down" bulbs were not illuminated at the time of impact; however, the red "gear in transit" bulb exhibited deformation considered consistent with an illuminated or hot filament when shocked.

1.12.3 Flaps

The flap handle has three positions: UP, TO (take-off or approach), and DOWN. The flap handle was found to be bent and in the UP position; however, it could not be determined if it had been driven to the UP position during impact. The extension of the left and right flap actuators was measured and found to be symmetrical, with an approximate 11.25- to 11.35-inch extension. A flap actuator extension of 11.42 inches corresponds to a flap setting of 10 degrees, or 25 per cent, the TO position (approach flap).

1.12.4 Flight Control Systems

The elevator, rudder, and aileron are equipped with a trim system with manually operated cockpit controls that have a selection range from 1 to 6 on either side of a 0, or neutral, position. The elevator trim indicator was found at the top of the green range or at the 1 indicator position (towards nose UP). The rudder trim indicator was found between the 0 and 1 nose-right position and the aileron trim indicator was found between the 0 and 1 right-wing-low position. All trim positions were indicative of a neutrally trimmed aircraft.

The flight control cable routing, integrity, and security through the wings, cabin, and tail sections were examined by the TSB Engineering Branch, and no faults in these systems were found.

1.12.5 Engine Examination

The engines (Pratt & Whitney PT6A-34) were removed from the occurrence site and taken to the manufacturer's service investigation facility at Saint-Hubert, Quebec, for examination under the control of the TSB. The results of the investigation are contained within a teardown and examination report prepared by Pratt & Whitney Canada for the TSB. The engine examination revealed no mechanical, manufacturing, assembly, or maintenance-related anomalies that would have affected engine operation. The report concluded that, based on impact-related damage, both engines were likely operating in a mid- to high-power range at impact.

1.12.6 Auto-feather System

The two green auto-feather armed lights were examined by TSB Engineering Branch personnel and were considered to be ON at impact. The company E110 SOP manual, Approach & Landing Procedures Section states: "If icing is anticipated, turn on the anti-ice. Arm the auto-feather, and turn off the prop sync."

1.12.7 Propeller Examination

The propellers (Hartzell HC-B3TN-3C/3D) were removed from the occurrence site and taken to manufacturer's service investigation facility in Piqua, Ohio, for examination under the control of the TSB. The results of the investigation are contained within a teardown report prepared by Hartzell Propellers for the TSB. The propeller examination revealed no mechanical, manufacturing, assembly, or maintenance-related anomalies that would have affected propeller operation. The report concluded that both propellers were in a thrusting mode of operation (normal governing range) and absorbing a similar amount of engine power at impact.

1.12.8 Instrument Examination

An examination of the instruments at the site revealed that both the captain's and first officer's altimeters had been set to 30.05 (the setting that was passed to the crew by the APM at Little Grand Rapids). The aircraft clock had stopped at 1526, the aircraft radios were set to 122.8 MHz (UNICOM frequency) and 130.07 MHz (company frequency), and the windshield defog switch was in the ON position. The airspeed indicators, fuel flow gauges, and fuel quantity gauges were sent to the TSB Engineering Branch Laboratory for examination (LP 193/97).

The TSB Engineering Branch found that both airspeed indicators displayed internal damage. Both instruments indicate the speed at impact to have been in the 138- to 153-knot range.

The left engine fuel flow indicator pointer was indicating a minimum of 325 pounds per hour at impact (the maximum gauge reading is 500 pounds per hour). The right fuel flow indicator provided no information. The left and right fuel quantity gauges displayed needle imprints at 640 pounds and 380 pounds respectively. The gauges return to zero by an internal spring when power is removed; therefore, the fuel quantity readings were considered minimum readings at the time of impact. The fuel quantity gauge range is from zero to 1 650 pounds.

1.12.9 Global Positioning System

The GPS, a II Morrow Classic, model 820, was removed from the occurrence site and forwarded to the manufacturer's facility in Salem, Oregon, for data retrieval. A representative of the U.S. Federal Aviation Administration (LP 193/97) was present at the request of the TSB. The system software version was current and appropriate, the manual altitude setting was 700 feet, and there was no active flight plan inserted. The last recorded waypoint was latitude 52°02'73" N, longitude 095°27'93" W and identified as CZGR. The last

recorded aircraft position was latitude 52°02'34" N, longitude 095°27'58" W, with a magnetic bearing and distance to the last recorded waypoint of 333 degrees at 0.4 nautical mile. The last recorded waypoint corresponded to the ramp (mid-runway location) at the Little Grand Rapids airport. The last recorded aircraft position corresponded to the position of the crash site.

A check with the operator found that the original GPS, a II Morrow Classic, had been replaced with a more advanced Apollo GX55. The GX55 was then removed from the aircraft due to a card incompatibility and temporarily replaced with a II Morrow Classic (the occurrence GPS) from another company aircraft (a float-equipped DHC-2 Beaver). The mounting tray installation and aircraft antennae systems for both styles of GPS were compatible. Neither GPS had been coupled to the aircraft's navigational equipment.

The II Morrow Classic GPS installation did not meet the requirements of the technical standard order for IFR GPS receivers (technical standard order C-129); therefore, the GPS was not approved for use as primary IFR flight guidance.

The Beaver aircraft had been operating at the company float base at Little Grand Rapids, which is across the lake from the airport, near the community. The coordinates of the float base had been entered into the GPS under the identifier ZGR. The Bandeirante aircraft passed near the float base on its final approach to the airport; however, it was not established if the crew had been using float base coordinates as a point of reference because the second-last selected waypoint is not stored information.

1.12.10 Fuel Samples

A fuel sample was secured from the company's fuelling facility at the St. Andrews airport. The fuel was identified as Jet-B. A visual examination showed it to be clean and bright, and free of contaminants. The company's fuel cache of Jet-B at Little Grand Rapids had been run dry before the accident and was not being used. The pilot of the aircraft was aware of this.

During impact with the trees, the fuel tanks were ruptured and fuel was dispersed along the wreckage trail. Very little fuel was found in the damaged fuel tanks.

1.13 Medical Information

An autopsy and toxicological tests were conducted on the captain. The toxicological tests indicated the presence of the non-prescription drug, diphenhydramine, in some body fluids but not in the blood sample. The testing found that the captain's blood had a four per cent saturation level of carbon monoxide. The captain was reported to have been a non-smoker. The source of the carbon monoxide was not determined. However, second-hand smoke could account for a four per cent saturation level. Diphenhydramine is a drug with sedative, antihistamine, and antiemetic effects. It is commonly used to treat motion sickness and can be found in non-prescription cold or flu medicine. The absence of the drug in the captain's blood stream likely indicates that the drug was nearly eliminated from his body before the time of the accident. There was no indication of any other pre-existing conditions that could have affected the captain's performance.

1.14 Fire

A small post-crash fire started in the area of the left engine. Passengers quickly extinguished the fire with snow.

1.15 Survival Aspects

1.15.1 Aircraft

The fatalities and the most serious injuries occurred to the occupants in the cockpit and the first two passenger rows. The extensive damage to the front of the aircraft destroyed the liveable space surrounding the occupants. The passengers in the remaining rows suffered varying degrees of somewhat less serious injuries, as the cabin structure remained intact.

The two forward doors were destroyed and blocked by debris. The passengers in the rear rows were able to open the over-wing, emergency exit doors and egress through them. Several of the passengers were trapped amid the debris and rescue workers had to move portions of the forward cockpit structure to extract them.

The survival gear was stored in the back of the aircraft and was easily accessible after the crash. The first-aid kit, however, was located in the front of the aircraft and was buried within the crushed structure. In this occurrence, neither kit was necessary because of the prompt emergency response; however, the inaccessibility of the first-aid kit would have made it difficult for the survivors to treat the injuries.

The Little Grand Rapids airport is equipped with a fire truck, which was driven onto the frozen lake surface and to the shoreline near the crash site. The fire truck responded within minutes of the accident but was not needed because the small post-crash fire had been extinguished. First at the crash site were residents, who arrived on snowmobiles and helped to organize rescue operations and to stabilize the survivors, who were then transported via snowmobile and sled to the nursing station across the lake at the community of Little Grand Rapids. Three of the more seriously injured were flown to Winnipeg on the company's Navajo that had landed

minutes before the accident. Military rescue operations were hampered by poor weather conditions and the remaining passengers could not be transported to Winnipeg until the following day.

1.15.2 Emergency Locator Transmitter

The emergency locator transmitter (ELT) was identified as a Dorne & Margolin, serial number 32527, which had been re-certified with a new battery on 07 November 1997. The ELT was found in the ARMED position and had activated upon impact. A military search and rescue aircraft picked up an ELT signal in the area of the crash site; however, the signal was very weak.

An examination of the ELT at the occurrence site found that the antenna cable had pulled out of the aerial at the connector fitting. The antenna cable was found to be looped together and wrapped tightly with "Ty-Rap," effectively taking slack out of the cable. During the impact sequence, there was sufficient movement and flexing in the fuselage structure to cause the antenna cable to be pulled out of the connector fitting.

1.16 Tests and Research

Not applicable.

1.17 Organizational and Management Information

1.17.1 General

At the time of the accident, Sowind Air Ltd. operated a fleet of eight aircraft, which included three Piper Navajos, two Cessna 185s, one DHC-2 Beaver, one DHC-3 Otter, and the Bandeirante. The company had been formed in 1992 to provide scheduled and charter service between northern communities and St. Andrews. In 1996, the company acquired the Bandeirante. With the implementation of the Canadian Aviation Regulations (CARs), the smaller aircraft were operated under part 703, Air Taxi Operations, and the Bandeirante was operated under part 704, Commuter Operations.

1.17.2 Senior Management

At the time of the accident, Sowind Air Ltd. was a privately owned company with three directors including the president. Reporting to the president were an operations manager, a chief pilot, and a maintenance coordinator. The president indicated that he was primarily responsible for the financial and other non-flying aspects of the company. The operations manager was responsible for the day-to-day flying operations and the chief pilot was responsible for the training of pilots and the procedures used by them. The president retained

control of the hiring practices of the company. The president indicated that he had started the company to provide a higher standard of service to the northern communities served by the company.

The operations manager had been with the company since it started. He indicated that he considered his duties to include the general supervision of flight dispatching and flying administration, such as flight times and log books. A self-dispatch system was in place for all flights, and because the operations manager flew as a line pilot, he was not always present to supervise the aircraft loads and weather accepted by pilots. The pilots dealt directly with the passenger clerks and freight handlers as a matter of routine.

The chief pilot, who was the occurrence captain, had been chief pilot for seven days at the time of the accident. The previous chief pilot had been with the company since its inception and had been responsible for the training of pilots and the establishment of procedures during the introduction of the Bandeirante and the start-up of commuter operations.

1.17.3 Flight Operations

In general, the pilots did not believe there was management pressure to fly in marginal weather. However, there was a belief that there was little concern for accurate weighing of cargo and passenger baggage. Specific examples of inaccurate weight and balance control were discussed with investigators. The previous chief pilot indicated that sample weight and balance calculations had been made to assist pilots; however, no sample calculations were found. It was determined that pilots used the GPS to assist in approaches in IFR conditions and that some pilots engaged in the practice of entering runway thresholds as waypoints for the conduct of approaches.

1.17.4 Maintenance Department

In 1993, Sowind Air Ltd. established an approved maintenance organization (AMO 7693) to maintain fixed-wing, piston aircraft. The company employed two licenced engineers and two apprentice engineers. Neither the company's AMO nor the company's maintenance staff were certified to maintain the Bandeirante, and the maintenance of the aircraft was contracted to Northeastern Aircraft Sales & Service, which held the appropriate qualifications. The company subsequently produced a new maintenance control manual (MCM) as required by CAR 726.08. The MCM was approved by TC on 14 November 1997. The MCM indicated that an approved maintenance agreement was in effect with Northeastern Aircraft Sales & Service for maintenance of the Bandeirante.

There were maintenance concerns that pilots had moved equipment from aircraft to aircraft without coordination with the maintenance department.

1.17.5 Transport Canada Safety Oversight

Air carrier audits were conducted on Sowind Air Ltd. in September 1993 and 1994 by TC. These audits identified a small number of non-conforming items, all of which were corrected to TC's satisfaction. Similarly,

TC maintenance audits, conducted in May 1994 and December 1995, identified maintenance non-conformances that were subsequently corrected. A post-occurrence audit of Sowind Air Ltd. was conducted from 12 to 14 January 1998 by TC, with 32 non-conformances identified. The audit found that the operations manager was not fulfilling the responsibilities of the position. There were several non-conformances with respect to training. These non-conformances indicated that no company pilots, including both occurrence pilots, had received required training in the use of onboard survival or emergency equipment. Additionally, the captain had not undertaken required training to operate the aircraft from either pilot seat. The audit also revealed that, in the months of September and December before the occurrence, the maximum take-off weight of the occurrence aircraft had been exceeded on seven flights.

TC inspectors had a good working relationship with Sowind Air Ltd. personnel; problems were dealt with positively, and TC inspectors did not feel there were significant problems in the company. The TC Manual of Regulatory Audits specifies that an initial certification audit will normally be conducted approximately six months after the certification date. Because Sowind Air Ltd. had been certified to use the Bandeirante in commuter operations in the fall of 1996, an initial certification audit should have been conducted in the summer of 1997, before the occurrence. TC officials explained that audits were suspended for approximately one year following the introduction of the new CARs in October 1996. This was done to allow both the industry and TC to adjust to the new regulations and to accommodate the heavy workload related to implementation of the new regulatory philosophy and process in TC.

TC uses an activity reporting and standards system (ARASS) to assist management in analysing operational workload and resource requirements. The ARASS is composed of discretionary and non-discretionary tasks. The review of initial weight and balance reports is deemed a discretionary task dependent on the workload of the assigned inspector. At one time, TC attempted to review all weight and balance reports submitted by operators, but found the workload prohibitive. The weight and balance report for the Bandeirante was received by TC and placed in the aircraft's file. The information contained within the reports was not reviewed.

1.18 Additional Information

1.18.1 Controlled Flight into Terrain

Controlled flight into terrain (CFIT) accidents are those accidents in which an aircraft, capable of being controlled and under the control of the crew, is flown into the ground, water, or obstacles with no prior awareness on the part of the crew of the impending disaster.

1.18.2 False Climb or Somatogravic Illusion

The somatogravic illusion occurs in conditions of poor visibility or in darkness when there is an absence of visual cues. Instrument-rated and experienced pilots are not immune to this illusion, which is a subtle and dangerous form of disorientation. The illusion occurs because the body relies on sense organs in the inner ear to maintain balance and, in the absence of visual cues, signals from these organs can produce a very powerful disorientation. In the case of an aircraft that is accelerating during a missed approach, the sense organs of the inner ear of the pilot send a signal to the pilot's brain that is interpreted as tilting backwards instead of

accelerating forward. If the aircraft nose is simultaneously raised, which is usually the case in a missed approach, the pilot has a very strong sensation of climbing. The illusion of false climb tends to lead the pilot to lower the nose and descend. The aircraft then accelerates and the illusion can intensify. If the aircraft is being flown in proximity to the ground, ground contact can occur before the pilot can assimilate information from the aircraft's instruments, overcome the powerful illusion, and take corrective action.

1.18.3 Carbon Monoxide

Levels of carbon monoxide saturation of less than 10 per cent are not considered to have a major effect on performance, although such a level would have a greater effect on non-smokers than on smokers. Cigarette smokers, for example, may routinely have saturation levels of 6 to
8 per cent. Carbon monoxide saturation levels can also be increased in non-smokers where an individual is exposed to second-hand smoke in an enclosed area. When saturation levels exceed 10 per cent, headache and shortness of breath can occur.

1.18.4 Aeromedical Factors

The *Aeronautical Information Publication* (AIP) refers to self-medication in sections Air 3-1 and 3-12. In section Air 3-1, the AIP states that, while flying an aircraft, a pilot must have no condition that impairs alertness, reaction time, or decision-making ability. Individual pilots must make the decision whether they are fit to fly based on common sense and training. Section Air 3-12 states that self-medication, or taking medicine in any form immediately before or while flying, can be hazardous. The section explains that certain drugs, the most common being antihistamines, have been associated with aircraft accidents in the past and may seriously impair the judgement and coordination needed by a pilot.

1.18.5 Sowind Air Ltd. Approach and Landing Procedures

Sowind Air Ltd. SOPs specify that the pilot-flying will brief the approach applicable to the runway of intended landing. The applicable instrument approach plate will be available and visible to both the pilot-flying and the pilot-not-flying throughout the approach to landing. The

approach plates found in the wreckage, including the plate for Little Grand Rapids, were in a three-ring binder and not in the approach plate holder. The three-ring binder was found under the captain's seat.

1.18.6 Operations in Marginal Weather

The aircraft was observed operating at low level, at an altitude of 150 feet agl, in ceilings of 100 to 200 feet agl and visibility of one to two miles. In two earlier safety recommendations (A96-11 and A96-12), the TSB recommended that the Department of Transport raise commercial operators' awareness of the inherent risks associated with operations in marginal weather, and require pilots involved in air taxi and commuter operations to receive specialized training in making prudent decisions under deteriorating operational conditions.

1.18.7 Commuter VFR Flight Obstacle Clearance Requirements

CARs, part 704, governs commuter operations. CAR 704.23 restricts commuter aircraft in day VFR operations to a minimum of 500 feet agl and not less than 500 feet horizontally from any obstacle.

2.0 Analysis

2.1 General

There was nothing found in the examination of the wreckage or in the detailed examination of individual components to suggest that the aircraft had experienced a structural failure, flight control malfunction, or loss of engine power that would have caused the observed approach and manoeuvring. Consequently, the analysis will be primarily concerned with the local weather, the possibility of aircraft contamination, the aircraft's weight and balance, CFIT, the crew's decision making and actions, and management.

2.2 The Weather in the Vicinity of Little Grand Rapids

Because there is no official weather observer or automated weather station at Little Grand Rapids, the available local weather information is that which has been reported by pilots. The estimated local ceilings and visibilities, as reported by two pilots, were generally lower than the official area forecasts because of the influence of the open, rapidly flowing water close to the airport. One report estimated the ceiling as indefinite from 100 to 200 feet agl with a visibility of one statute mile. The other report estimated the ceiling as 300 feet agl with a visibility, when landing on runway 18, of two statute miles. Both of these ceiling estimates were below the minimum descent altitude (MDA) for the NDB A approach and below the minimum altitude for commuter operations. Of more significance was the report that the fog from the open water had drifted to the east of the airport and extended to tree-top level. Thus, Sowind Air Ltd. Flight 301, while flying below the cloud layer to the east of the track below the MDA, was flying directly towards a fog bank extending from the white, frost-covered tree tops to the cloud layer. In the area of the fog, the ceiling and visibility were much lower than over the runway, and the frost-covered trees blended into the fog layer, virtually eliminating all outside visual reference for the crew of Sowind Air Ltd. Flight 301.

2.3 Aircraft Contamination

Because moderate mixed icing was forecast in freezing drizzle, with light rime icing elsewhere, it is possible that the aircraft's flying surfaces were being contaminated. The reports of witnesses indicated that there was no freezing drizzle in the area of Little Grand Rapids during the period of the flight from Winnipeg. The icing on the wing of the aircraft reported by one passenger was white and was not flowing back from the leading edge. The ice on the windscreen reported by another passenger was described as similar to frost patches. Both of these reports are consistent with the presence of rime ice. The pilot who examined the aircraft a few hours after the crash found only a trace of rime ice on the vertical fin of the aircraft. There were no signs of either clear or rime ice found by investigators on the day following the accident, although the

temperature had remained below freezing and the aircraft was under both cloud cover and tree canopy. Consequently, it is likely that only small amounts of light rime ice formed on the aircraft before the occurrence.

The ice was observed on the windscreen, so the crew would have known that ice was present and would have had the opportunity to deal with it. Because little ice was found immediately after the accident, it is concluded that the crew took appropriate action, and aircraft contamination was being reduced by the aircraft's systems to the extent possible. However, even small amounts of rime ice would cause a small increase in stall speed, and any residual contamination on the aircraft windscreen would have reduced the crew's ability to see the terrain. Because all trims were found in a neutral position, it is unlikely that any trace amounts of ice were reducing control effectiveness.

2.4 Weight and Balance

Although the weight of the aircraft at impact could not be determined with precision, it was determined to be 495 pounds to 1 095 pounds greater than its maximum allowable landing weight, and 10 pounds to 610 pounds greater than its maximum allowable take-off weight. Using the stall speeds presented in the approved flight manual for 12 500 pounds (and a factor of about three knots' increase for each additional 500 pounds), Figure 2 presents an approximation of the stall speeds of the aircraft weighing 500 pounds more than the maximum take-off weight at various bank angles.

Degrees of bank	Stall (KIAS)
0	88
30	94
45	104
60	124

While the airspeed at which the aircraft was flown is not known, the flight should have been operating at 120 KIAS based on the Sowind Air Ltd. SOPs, and the TSB Engineering Branch determined that the indicated airspeed at impact was between 138 and 153 KIAS. Therefore, the airspeed of the aircraft during the approach was probably in the range of 120 to 153 knots. Using the above chart, it can be seen that the crew would have to have entered a sustained bank of more than 45 degrees to stall the aircraft at the low end of this speed range. While the passengers described the bank applied immediately before the crash as extremely steep, in the absence of FDR information, the bank angle achieved was not determined. While it is unlikely that the captain would have initiated a bank of more than 30 degrees at low speed and at low level, a bank angle greater than 30 degrees cannot be discounted. However, even at an aggressive bank angle of 45 degrees, the approximate stall speed is 104 KIAS, leaving a 16-knot margin for an increase in stall speed because of residual rime ice. Thus, a stall caused by a combination of weight, bank angle, and contamination is not considered likely.

2.5 Controlled Flight into Terrain—Flight Crew Performance

2.5.1 Decision Making

The captain attempted a second approach after communicating with the pilot of the Navajo, Sowind Air Ltd. Flight 318. It is reasonable to conclude that the information provided by the Navajo pilot influenced the captain's decision to attempt a second approach and subsequent actions on approach. Because the captain had a reputation for "pushing the weather," the knowledge that a company aircraft had just landed was likely a factor in his decision to descend below the MDA and the minimum altitude for commuter operations and attempt a visual approach in marginal conditions.

Because passengers were able to discern that the aircraft was well east of the normal track, the crew members, who were very familiar with the area, should also have known that the aircraft was out of position for an approach to land. The reason that the aircraft was flown to the east of the normal approach was not determined.

The presence of diphenhydramine likely indicates that the captain was recovering from a cold or the flu. The toxicology results confirmed that the drug was nearly eliminated from his body at the time of the accident. The residual effects of the illness or the diphenhydramine, combined with the elevated level of carbon monoxide (for a non-smoker), could have reduced the captain's decision-making ability and level of alertness and delayed his reaction as a dangerous situation developed. However, there was no other information directly supporting this possibility.

2.5.2 Crew Resource Management Training

Records indicate that the first officer had completed a TC pilot decision-making course and that he had previously objected to unsafe practices and procedures; there was no information recovered regarding his actions during the occurrence flight.

2.5.3 Somatogravic Illusion

Information from eyewitnesses placed the aircraft at about 150 feet above the lake surface, well to the right of the normal approach path, at about one and a half miles from the airport. The aircraft was thus about the height of the top of the fire tower, which was about 163 feet above the lake surface. Because the aircraft was flying to the right of the normal approach path, the fire tower was between the flight path and the runway. Eyewitnesses indicated that, as the aircraft approached the shoreline, the engine power was advanced and the aircraft banked to the left and then immediately banked to the right before descending into the terrain. It is possible that the crew observed the fog to the east of the airfield, initiated an overshoot, and turned to the left to remain clear of the fog. Witness statements that the power was advanced, and the illumination of the "landing gear in transit" light, support this interpretation. After the bank to the left was applied, it is possible that the fire tower was observed and the captain immediately banked right to avert a collision. In that case, the aircraft would have turned back towards (or entered) the fog bank, and the crew would have had to transition immediately to instrument flying techniques and initiate a climb. Because the aircraft was not equipped with a CVR, the

decisions taken by the crew cannot be known with certainty. However, it is possible that the application of power induced a somatogravic illusion in the crew members, leading them to believe that they were in a climb rather than a descent. In such a situation, the captain would have flown the aircraft into the terrain, believing that he was climbing up through the cloud layer.

2.6 Ground Proximity Warning

A GPWS, if installed and operable, would have provided appropriate warnings and cues to the crew members of their proximity to the terrain. However, since the crew members were flying below authorized altitudes, it is unlikely that they would have responded to GPWS advisories.

2.7 Cockpit Voice Recorder

A CVR, if installed, would have provided valuable information in the determination of what took place in the minutes preceding the accident; TC had granted an exemption until 01 August 1998 for operators to comply with the requirement of CAR 605.33 (2) that a CVR be installed in this particular type of aircraft.

2.8 Transport Canada Monitoring

2.8.1 Transition to Commuter Operations

The audit history of Sowind Air Ltd. and the positive relationship that existed between the company and TC inspectors did not indicate to TC any need for special attention during the introduction of the Bandeirante. Further, because TC policy suspended audits during the introduction of the CARs, the initial certification audit was not accomplished. Because TC inspectors believed that Sowind Air Ltd. was conforming to the aviation regulations and standards, there was no reason to override the audit suspension policy and audit the company. However, the significant number of audit findings, made during the post-occurrence audit, indicates that the company had difficulty with the transition from an air taxi operator to a commuter operator. Given that TC officials were of the opinion that the company had been well-managed and could cope with the transition, it is likely that the transition difficulties faced by the company were underestimated by TC.

2.8.2 Weight and Balance Monitoring Policy

TC's weight and balance policy allowed the basic weight and balance calculations of a commuter type aircraft to be accepted without any review for accuracy. A significant number of discrepancies developed (see Appendix C) and were not detected or resolved. Consequently, the occurrence aircraft, C-GVRO, was operated for approximately one year, and over a wide range of loads, without accurate weight and balance calculations.

2.9 Company Management

Company management, as assessed by TC audits and inspections, had been deemed satisfactory before the introduction of the Bandeirante. As revealed by the post-occurrence TC audit, the management of the company had not dealt effectively with the introduction of the Bandeirante. While the president stated that the policy was to provide a higher standard of service, and that the company's first concern was safety, safety was compromised in three areas of management responsibility: training and standards, operations, and maintenance.

The investigation revealed that the chief pilot's operational control diminished during the introduction of the Bandeirante. Over time, the weighing of cargo and passenger baggage became less effective, and GPS was used routinely on approaches in IFR conditions contrary to the provisions of the CARs. The operations manager exercised little influence in the commuter operations, primarily flying in the air taxi operation and providing little supervision.

2.10 Global Positioning System

The use of the GPS during the occurrence approaches was not confirmed. However, the GPS was selected to a waypoint that corresponded to the mid-point of the airport, and the GPS would have provided both track guidance and distance to the airport. Because the crew members descended through the cloud layer to an altitude that was some 400 feet below the MDA, it is likely that they were utilizing the distance to the airport provided by the GPS as a means to descend to establish visual contact with terrain. Other company pilots indicated that the GPS was used in this manner on other occasions.

The TSB has made a safety recommendation (A95-07) to expedite the implementation of approved GPS standards and procedures for use in Canadian airspace. The TSB has also recommended (A95-08) that TC initiate a national safety awareness program addressing the operating limitations and safe use of GPS in remote operations.

2.11 Emergency Locator Transmitter

The separation of the ELT antenna and consequent reduction in ELT signal strength had no effect on the outcome of the occurrence because ground rescue parties knew the position of the aircraft. However, the absence of a strong ELT signal would have delayed search and rescue response if the aircraft wreckage had been located a greater distance from the local community.

2.12 Operations in Marginal Weather

In 1996, the TSB brought safety recommendation A96-11 to the attention of the Minister of Transport, as the Board believed that there was inadequate understanding throughout the aviation community of the risks and consequences of operating in marginal weather conditions. The recommendation was for the Department of Transport to develop and implement a targeted national promotion campaign to raise commercial operators' awareness of the risks associated with flight operations in marginal weather. TC, in its response, stated that it would undertake new initiatives in response to recommendations from the Safety of Air Taxi Operations (SATOPS) Task Force and consideration of a targeted national promotion campaign would be done at that time.

The Board also believed that, given the natural human limitations in interpreting distances in conditions of marginal visibility, the natural human tendencies in complex decision making in the presence of changing and ambiguous cues, and the CFIT accident record involving small commercial operators, further counter-measures were required to facilitate safe crew decision making. To that end, the Board recommended that the Department of Transport require that pilots involved in air taxi and commuter operations receive specialized training, including skills development, in making prudent decisions under deteriorating operational conditions (A96-12). TC, in its response, stated that it would task the Canadian Aviation Regulation Advisory Council (CARAC) to study and develop whatever additional specialized training may be required so that pilots involved in air taxi and commuter operations are fully capable of making prudent decisions under deteriorating operational conditions.

The SATOPS Report, finalized on 28 May 1998, addresses the issue of flight operations in reduced visibility. It concludes that "pilots are still pushing the weather," and recommends that a one-time attendance of the pilot decision-making course may not be sufficient for reduced visibility operations.

2.13 Summary

The company did not make the transition well from air taxi operations to commuter operations, and did not handle the introduction of the Bandeirante safely. TC's policies reduced monitoring in critical areas, and the transition problems the company was experiencing were not identified. The occurrence flight was dispatched overweight into marginal weather with a captain known to continue in marginal weather. After completing a missed approach, the captain began a second approach after receiving weather information from a company aircraft that had landed. The occurrence aircraft was observed at low level, below the MDA and the minimum en route altitude for commuter operations, to the east of the approach path and heading for the fog-covered terrain. Witness observations support the possibility that the crew initiated an overshoot in the

vicinity of a fire tower and then manoeuvred to avoid the tower. Conditions were conducive to somatogravic illusion in whiteout conditions. It is likely that the captain flew the aircraft into the terrain under the illusion that the aircraft was climbing.

3.0 Conclusions

3.1 Findings as to Causes and Contributing Factors

1. At the time of the occurrence, the base of the cloud at Little Grand Rapids was between 100 and 300 feet agl, with fog to the east of the airport, and the visibility was one to two miles.

2. The aircraft was flown in marginal weather at low level, below the minimum en route altitude for commuter operations and below the MDA for the NDB A approach at Little Grand Rapids. The MDA for the approach was 1 560 feet asl, 555 feet above the airport elevation.

3. While the aircraft was being manoeuvred at very low level in marginal weather, it descended after an abrupt turn, and flew, in controlled flight, into the terrain.

3.2 Other Findings

1. At both take-off and landing, the aircraft was about 1 000 pounds heavier than the relevant maximum allowable weight.

2. The GPS installed in C-GVRO was not approved as a primary navigational aid. The available information indicates that the flight crew used the GPS as a primary navigational aid during the last approach to Little Grand Rapids.

3. The aircraft was not equipped with a GPWS, nor was it required to be by regulation.

4. The weight and balance report that was submitted to Transport Canada, required for the importation of C-GVRO, contained numerous discrepancies; the report was not reviewed for accuracy by Transport Canada.

5. The emergency locator transmitter (ELT) produced a very weak signal because the antenna cable had been installed with little slack, and it pulled out of the antenna fitting during impact.

6. It could not be determined whether the presence of carbon monoxide and diphenhydramine in the captain's body affected his decision making and level of alertness.

7. The company, which had been an air taxi operator, did not effectively manage either the addition of the more complex commuter operations or the introduction of the larger Bandeirante aircraft.

8. The difficulty that the company had in the transition to commuter operations and in the introduction of the Bandeirante aircraft was underestimated by Transport Canada.

9. There were inadequacies in TC's oversight, whereby the post-certification audit of the company was not conducted, thus eliminating an important mechanism by which TC could have found, and

addressed, the inadequate safety management practices, non-conformance with pilot training requirements, and related operating irregularities.

10. The pilots had passed their flying proficiency and medical tests, but they had not completed elements of pilot training requirements with respect to servicing and operational control and right seat conversion as prescribed by TC. Also, no company pilot had received required training in the use of onboard survival or emergency equipment.

11. There was no indication found of any pre-impact failure or malfunction of the airframe, flight controls, or engines.

12. The aircraft was not equipped with either a CVR or an FDR; TC had given the company an exemption to operate without a CVR until 01 August 1998, and the aircraft was not required to be equipped with an FDR.

13. The absence of recorders on this aircraft, which was configured to carry 20 people, left many of the otherwise ascertainable facts associated with the accident unknown and reduced the opportunity of uncovering risks to safety associated with the flight.

14. Conditions were conducive to the pilot experiencing a false sensation that the aircraft was climbing (somatogravic illusion) after increasing the engine power, and he may have been manoeuvring to avoid an abandoned fire tower.

4.0 Safety Action

4.1 Action Taken

4.1.1 Transport Canada Post-Occurrence Audit

In January 1998, TC conducted a post-occurrence audit of Sowind Air Ltd. The findings of this inspection, primarily with respect to training shortcomings, and the lack of qualified management personnel resulted in the voluntary suspension of the company's air operator certificate. The company's subsequent response to the identified shortcomings resulted in the reinstatement of the air operator certificate.

4.1.2 Global Positioning System

The NAV CANADA SAT NAV office is working in cooperation with TC and the U.S. Federal Aviation Administration to implement a phased approach to the full realization of GPS for all phases of flight in Canada. In the SATOPS Report, it is recommended that TC continue to publish articles in the Aviation Safety Letter and Aviation Safety Vortex newsletters about the safe, proper use of GPS and the hazards associated with its misuse. TC has issued Special Aviation Notices, Aeronautical Information Circulars, made entries in the Aeronautical Information Publication (AIP) and has published articles in the Aviation Safety Letter and Aviation Safety Vortex newsletters that address the operating limitations and safe use of GPS.

4.1.3 Operations in Marginal Weather

Subsequent to the TSB safety recommendation (A96-11) to raise commercial operators' awareness of the risks associated with flight operations in marginal VFR flight conditions, many of TC's national aviation safety promotional efforts, safety awareness programs and regional education programs have focused on the respect of weather.

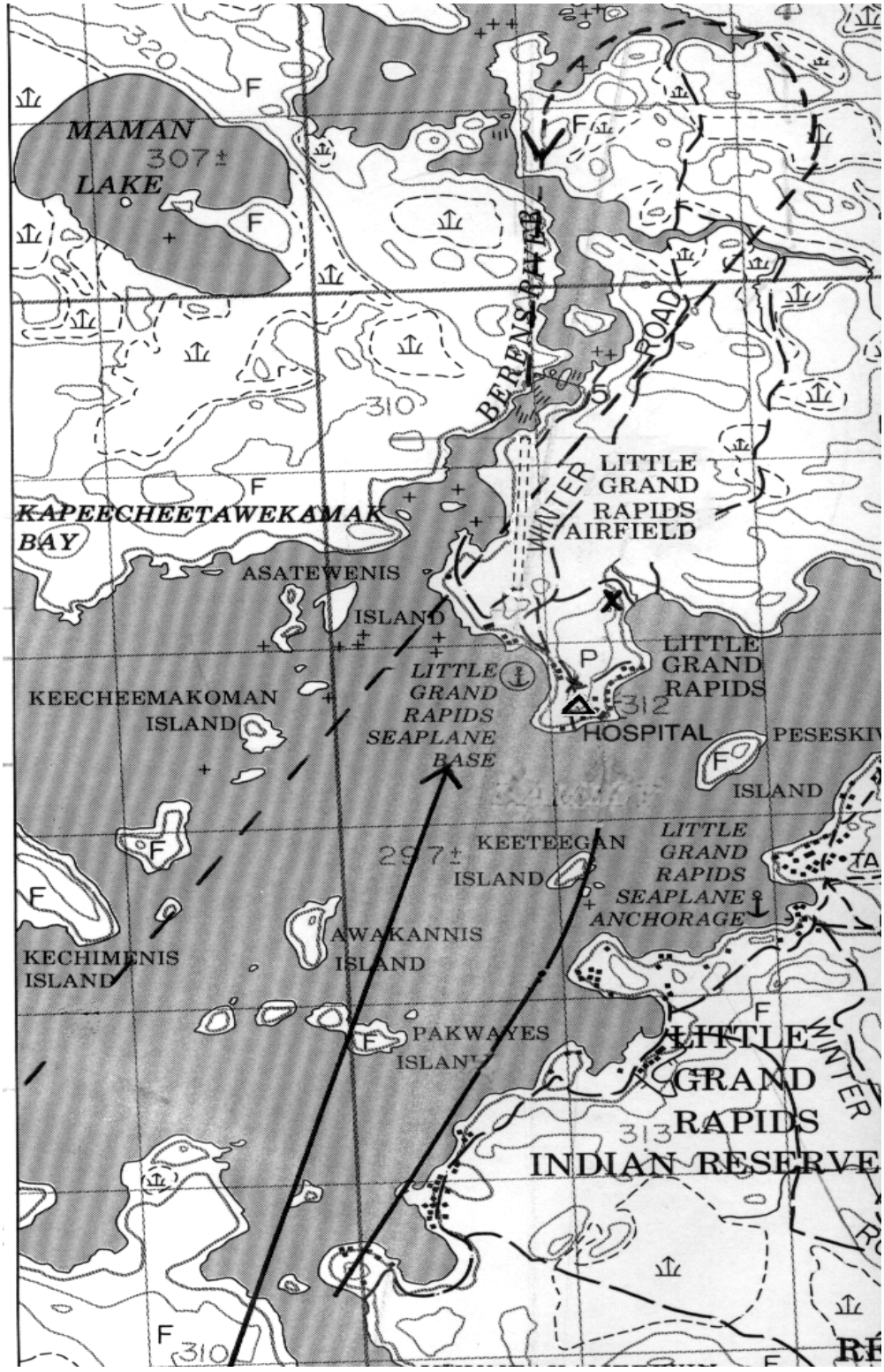
The TSB also recommended (A96-12) that pilots involved in air taxi and commuter operations receive specialized training in making prudent decisions under deteriorating operational conditions. Pilot decision making (PDM) has been addressed in the SATOPS Report, which recommends that TC review the Commercial Air Service Standard authorizing operations in reduced visibility (provided the pilot has taken a PDM course), to determine if one-time attendance at the PDM course is sufficient. As a result, TC is preparing a Notice of Proposed Amendment that will require annual PDM training for companies that hold the Operations Specification for operations in reduced visibility; this will apply to operators subjected to CARs 702, 703, and 704 (helicopters only).

A combined TC and industry study group is reviewing the safety data and issues surrounding approaches in poor weather. Regulatory recommendations concerning approach bans in the form of a Notice of Proposed Amendment (NPA) are to be submitted to the General Operating and Flight Rules Technical Committee of TC in December 1999.

4.2 Safety Concern

The Board is concerned about the frequency of accidents involving airworthy aircraft and fit pilots conducting instrument approaches during conditions of low visibility and/or low ceilings. The TSB is currently analysing 19 such accidents that have occurred in Canada from 1994 to the present. The most recent of these was a fatal accident involving a Beech 1900D aircraft at the Sept-Îles airport in Quebec. The pilots flew the aircraft well below the minimum descent altitude for the published NDB approach. Further work is in progress to determine the nature and extent of any safety deficiencies evidenced by these accidents.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board, consisting of Chairperson Benoît Bouchard, and members Jonathan Seymour, Charles Simpson, W.A. Tadros and Henry Wright authorized the release of this report on 02 December 1999.



Appendix A - Approach Outlines

Appendix B - Weight and Balance Estimates for the Flight

Sowind Air Ltd. Embraer EMB-110P1 Bandeirante, C-GVRO, Serial No. 110-285			
Item	Weight (lb)	Arm	Moment
Basic aircraft (corrected)	7607	258.9	1969872.6
Unusable fuel (28 litres)	48.5	285.8	13861.3
Engine oil (17 litres)	35.5	226.4	8037.2
Crew baggage	10	129.9	1299
Flight manuals	12	129.9	1558
Survival gear	40	435.5	17420
Cargo net and straps	40	361.5	14460
Crew (winter weights)	376	115	43240
Equipped operating weight (without seats)	**8169**		**2069748.1**
Passengers and seats 1, 2 and 3	419.5 [a]	176.8	74167.6
Passengers and seats 4, 5 and 6	430.5	207.5	89328.7
Passengers and seats 7, 8 and 9	513.5	238.6	122521.1
Passengers and seats 10, 11 and12	513.5	269.7	138490.9
Passengers and seats 13, 14 and 15	607.5	301.7	183282.7
Passenger baggage	359.0 [b]	361.5	129788.5
Cargo (groceries)	574.0 [c]	361.5	207501
Fuel (on manifest)	1600	283.5	453600
Total weight at take-off (C of G position)	**13 230.0**	**263.4 (*19.7% MAC*)**	**3484153.9**
Fuel used prior to impact	-720.0 [d]	283.5	-204120
Total weight at impact (C of G position)	**12 510.0**	**262.2 (*18.2% MAC*)**	**3280033.9**
Cargo (unaccounted for)	200.0 [e]	361.5	72300
Fuel not shown on manifest	400.0 [f]	283.5	113400
Revised weight at take-off (C of G position)	**13 830.0**	**265.3 *(22.3% MAC)***	**3669853.9**
Revised weight at impact (C of G position)	**13 110.0**	**264.4 (*21.0% MAC*)**	**3465733.9**

C of G limits:Maximum take-off weight: 12 500 lb
255.5 inches to 272.0 inches aft of the
datum at 12 500 lb, or 9.5% to 31% MAC

Maximum ramp weight: 12 566 lb
Maximum landing weight: 12 015 lb

Notes on weight and balance estimates:

a) The passenger weights are standard winter weights of 188 pounds for an adult male, 141 pounds for an adult female, and 75 pounds for a child. These passenger and seat weights include seat weights of 43.5 pounds per row.

b) The baggage as weighed at the accident site. The flight manifest indicated a baggage weight of 295 pounds.

c) The cargo as weighed at the accident site. The flight manifest indicated a cargo weight of 150 pounds.

d) The fuel burn was based on 650 pounds per hour.

e) The weight of cargo from the earlier, cancelled flight that could not be accounted for by the company or by investigators at the occurrence site.

f) The total fuel at take-off was computed by adding the fuel burn to the fuel quantity gauge reading at impact.

Appendix C - Weight and Balance Discrepancies

Discrepancies noted in the Basic Aircraft Weight and Balance Report and Equipment Check List, dated 20 November 1996, and prepared during the re-weigh:

The basic equipment check list was not updated as to items installed at the time of the "re-weigh." Items such as the portable toilet and divider panel were still being shown as installed.

The weight and balance report datum location was incorrect, i.e. 306.8 inches from rear jack point, not from the main wheel axle, as stated.

The weight and balance report weighing diagram was incorrect; it should have been the jack point diagram Fig. 6.2, not 6.3, as provided.

The moment calculation for the nose wheel weight was incorrect on the weight and balance report. The moment calculation should have been 1080 x 99.3 = 107.2 (lb x in/1000), not 10.7, as stated.

The total moment and arm calculations on the weight and balance report were affected by the incorrect nose wheel moment calculation. The C of G location should have been 277.9 inches aft of datum at 37.9% MAC instead of 255.2 inches aft of datum at 9.1% MAC.

The scale figures, taken during the re-weigh, were incorrectly transcribed onto the weight and balance form, making the subsequent weight and balance calculations meaningless.

Discrepancies noted in the Operational Weight and Balance Report, prepared after the re-weigh:

The weights and moment arms of the passenger seats were not the same as the ones reported on the basic equipment check list.

The total engine oil (36.5 pounds) was not included in the equipped operating weight (EOW).

The unusable fuel (48.5 pounds) was not included in the EOW.

The survival gear (40 pounds) was not included in the EOW.

The aircraft documents (12 pounds) were not included in the EOW.

No allowance was made for crew baggage in the EOW.

The crew winter weights (14 pounds total) had not been converted as per SOP 2.5.7.

The cargo net and "herc" straps (41 pounds) were not included in the EOW.

No moment arm measurement was provided for the 6th row seat installation.

No conversion formula was provided on the balance sheets to calculate % MAC.

Discrepancies noted in the Flight Load Manifest dated 09 December 1997, completed before the flight:

The AUW was incorrectly calculated as 12 500 lb.

The baggage and freight at the occurrence site weighed 933 pounds. On the manifest, the baggage and freight was reported as 445 pounds, a difference of 488 pounds.

Less fuel was shown on the flight manifest than was indicated on the fuel gauges at the occurrence site (400 pounds less).

Standard passenger weights were used; however, at least two of the passengers weighed nearly double the standard weight (300+ and 255 pounds).

Other weight and balance discrepancies noted:

The locations of the passenger seats were not the same as the ones reported by the company on a sample loading graph.

No weight and balance form was found for the occurrence flight, nor could the company produce a sample form for a similarly loaded aircraft.

No sample weight and balance forms could be found for the full range of aircraft operations.

The company was not computing the individual moment arms of the separate aircraft compartments when cargo spanned more than one compartment. On the occurrence flight, cargo was placed in three compartments, but one moment arm (an incorrect one) was shown on the sample loading graph.

Appendix D - List of Supporting Reports

The following TSB Engineering Branch Report was completed:

LP 193/97 - Instrument Examination - C-GVRO

This report is available from the Transportation Safety Board of Canada upon request.

Appendix E - Glossary

agl	above ground level
AIP	Aeronautical Information Publication
AMO	approved maintenance organization
APM	airport manager
ARASS	activity reporting and standards system
ARCAL	aircraft radio control of aerodrome lighting
asl	above sea level
ATPL	airline transport pilot licence
AUW	all-up weight
CAR	Canadian Aviation Regulations
CARAC	Canadian Aviation Regulation Advisory Council
CFIT	controlled flight into terrain
C of G	centre of gravity
CVR	cockpit voice recorder
ELT	emergency locator transmitter
EOW	equipped operating weight
FDR	flight data recorder
GPS	global positioning system
GPWS	ground proximity warning system
IFC	instrument flight check
IFR	instrument flight rules
KIAS	knots indicated airspeed
lb	pound(s)
MAC	mean aerodynamic chord
MCM	maintenance control manual
MDA	minimum descent altitude
MHz	megahertz
N	north
NDB	non-directional beacon
NPA	Notice of Proposed Amendment
PDM	pilot decision making
PPC	pilot proficiency check
SATOPS	Safety of Air Taxi Operations
SOP	standard operating procedure
TC	Transport Canada
TO	take-off
TSB	Transportation Safety Board of Canada
UNICOM	a private advisory radio station located at an uncontrolled aerodrome
U.S.	United States of America
VFR	visual flight rules

W	west
'	minute(s)
"	second(s)
°	degree(s)