AVIATION INVESTIGATION REPORT
A99Q0151

CONTROLLED FLIGHT INTO TERRAIN

RÉGIONNAIR INC.
RAYTHEON BEECH 1900D C-FLIH
SEPT-ÎLES, QUEBEC
12 AUGUST 1999

Transportation Safety Board of Canada

Bureau de la scurit 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.

Aviation Investigation Report

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Synopsis

The Régionnair Inc. Raytheon Beech 1900D, serial number UE-347, operating as Flight GIO347, was on a scheduled flight from Port-Menier to Sept-Îles, Quebec, with two pilots and two passengers on board. The aircraft departed Port-Menier for Sept-Îles Airport at 2334 eastern daylight time (EDT). The aircraft crashed at 2357 EDT while on approach to the airport, one nautical mile short of the runway, in reported weather conditions of 200-foot ceiling and one-quarter statute mile visibility. A post-crash fire destroyed the wings, the engines, and the right midside of the fuselage. The captain was fatally injured. The first officer was seriously injured, and the two passengers received minor injuries.

Ce rapport est également disponible en français.

1.0 Factual Information

1.1 History of the Flight

The Régionnair Inc. Raytheon Beech 1900D, Flight GIO347, departed Port-Menier, Quebec, at 2334 eastern daylight time (EDT)[1] on a 25-minute scheduled flight to Sept-Îles. This was the return leg of the Sept-Îles–Port-Menier–Mont-Joli flight. The flight was pilot self-dispatched and departed under instrument flight rules (IFR) in controlled airspace. The first officer was at the controls of the aircraft for the duration of this segment of the flight and was sitting in the right-hand seat. The take-off and en route portions of the flight were uneventful. After departure from Port-Menier, the crew received a weather report from the Sept-Îles Flight Service Station (FSS), which reported the latest conditions at Sept-Îles Airport as follows: ceiling 200 feet above ground level (agl) and visibility 1/4 statute mile (sm) in fog.

The crew planned a straight-in approach to Runway 31, using solely the navigation guidance from the global positioning system (GPS) set up to provide distance and track readouts relative to the runway threshold. GPS coordinates of north 50°13'47", west 66°15'26" and an inbound track of 312° magnetic were entered as the waypoint. These coordinates correspond closely to the threshold and magnetic heading coordinates of Runway 31. The crew planned the following: the approach would be flown on an inbound track of 312°; the desired altitude/ distance aim points would be 400 feet agl at the ZV non-directional beacon (NDB) (the final approach fix), 300 feet agl at 2 nautical miles (nm), and 100 feet agl at 1 nm from the threshold waypoint; and, once at 100 feet agl, a shallow descent would be flown until the approach lights were seen. The minimum descent altitude (MDA) for the NDB approach for Runway 31, the only published approach to this runway, was 680 feet above sea level (asl), 506 feet above the threshold. There is no published GPS approach for Runway 31 at Sept-Îles Airport.

The descent from cruise flight into the aerodrome was started late, and the aircraft was high and fast during the approach phase to the NDB. From an altitude of 10 000 feet at 9 nm from the NDB, the rate of descent generally exceeded 3000 feet per minute (fpm). The aircraft crossed the beacon at 600 feet asl. For the last 30 seconds of flight and from approximately 3 nm from the threshold, the aircraft descended steadily at approximately 850 fpm, at 140 to 150 knots indicated airspeed, with full flaps extended. The captain coached the first officer throughout the descent and called out altitudes and distances. The ground proximity warning system (GPWS) "Minimums" activation sounded, consistent with the decision height (DH) selection of 100 feet, to which the captain responded with directions to continue a slow descent. The last call was at 30 feet, 1.2 seconds before impact.

Eight seconds before impact, the GPWS voice message "Minimums, Minimums" activated. The aircraft continued to descend and struck trees at 2357, in a near-level attitude, in an area of rising terrain. The captain was fatally injured, the first officer was seriously injured, and the two passengers received minor injuries. A

[1] All times are EDT (Coordinated Universal Time [UTC] minus four hours). See Glossary at Appendix E for all abbreviations and acronyms.

post-crash fire destroyed the wings, the right engine, and the right midside of the fuselage. The cabin area remained relatively intact, but the cockpit area separated and was crushed during the impact sequence.

1.2 Injuries to Persons

	Crew	Passengers	Others	Total
Fatal	1	-	-	1
Serious	1	-	-	1
Minor/None	-	2	-	2
Total	2	2	-	4

1.3 Damage to Aircraft

The aircraft was heavily damaged by the impact forces and the post-crash fire.

1.4 Other Damage

Trees along the impact path were broken and burnt; however, the wet atmospheric conditions prevented the fire from spreading. The surrounding terrain, consisting mainly of small-diameter, 20- to 30-foot coniferous trees in a sand base, was slightly damaged by heavy equipment during the rescue and recovery efforts.

1.5 Personnel Information

1.5.1 General

	Captain	First Officer
Age	39	28
Pilot Licence	ATPL	ATPL
Medical Expiry Date	01 April 2000	01 February 2000
Total Flying Hours	7065	2600
Hours on Type	606	179
Hours Last 30 Days	127	181
Hours Last 90 Days	337	368
Hours on Type Last 90 Days	198	128
Hours on Duty Prior to Occurrence	16	18
Hours Off Duty Prior to Work Period	8	9

1.5.2 The Captain

The captain began his aviation-related employment as an aircraft maintenance engineer (AME) and pilot with Aéro Nord Est in September 1986. He subsequently worked for Alexander Inc. from November 1987 to September 1991, initially as chief AME, then as chief pilot. He then acquired the company and renamed it Confortair. From March 1997 to March 1998, he also flew for Régionnair as captain on the Beech 1900C. In early April 1999, he began flying again, part-time, for Régionnair on the Beech 1900D while he was still president, operations manager, chief pilot, and chief AME of Confortair.

The captain successfully completed a pilot proficiency check and an instrument flight check as captain on the Beech 1900D on 05 April 1999. He held a Group 1 instrument rating, and his medical certificate was current. The captain's training records indicate that he was a smooth pilot who demonstrated good management and decision-making abilities. Most of his flying experience was acquired in Quebec's Basse Côte-Nord (Lower North Shore) area. He knew this area of operations very well and was familiar with the region's aerodromes and typical weather patterns. His most recent flight on the Régionnair Beech 1900D was on 08 July 1999, and he had conducted a number of flights for his own company after that.

On the day of the accident, the captain left his home around 0730. Before undertaking Flight GIO347, he conducted two half-hour flights at his own company, taking off at 0900 and 1400. While GIO347 was on the second leg of the flight, Port-Menier to Mont-Joli, the Régionnair president, who was flying in another aircraft, reportedly spoke to the captain of GIO347 on company frequency. The poor weather at Sept-Îles was apparently discussed, and it was suggested that the crew remain in Mont-Joli until the weather at Sept-Îles improved. After landing at Mont-Joli, the captain made one or two phone calls to persons unknown. The aircraft was on the ground at Mont-Joli for about 20 minutes. The Mont-Joli to Port-Menier flight, flown by the captain, was uneventful.

1.5.3 The First Officer

The first officer obtained his commercial licence on 26 August 1991. He obtained his flying instructor rating in early 1993 and was a flying instructor at Cargair from April 1993 to April 1994. During the next two summers, he was a flying instructor at Quebec Transportair and Confortair, respectively. He obtained his multi-engine Group I instrument rating on 17 July 1997 and his airline transport pilot licence (ATPL) on 25 August 1998. He flew for Aviation Québec Labrador as a captain on the Embraer 110 from June 1998 to April 1999. In April 1999, he began flying again for Confortair, part-time, and he joined Régionnair as a full-time pilot in June 1999. The first officer had an arrangement with Régionnair's management, allowing him to fly for Confortair when he was not required at Régionnair. Régionnair's chief pilot had requested that he provide the details of his flying hours conducted at Confortair monthly. The sum of his daily flight duty times for both companies was not recorded by Régionnair's management.

The first officer had a current medical certificate and a Group 1 instrument rating. He completed a crew resource management (CRM) course on 28 February 1999. After his initial ground school course and five hours of flight training on the Beech 1900D, he successfully completed a pilot proficiency check and an instrument flight check as first officer on 23 June 1999. His most recent Beech 1900D flight was conducted the day before the accident. It consisted of eight legs of approximately one hour each and ended at Sept-Îles at 1922. He got up at 0600 on the day of the accident for a scheduled take-off time of 0700 at Confortair. That flight comprised five legs for a total duration of 6.5 hours and ended at Sept-Îles at 1700. He took off at 2104 for the first leg of the occurrence flight, after having been on duty for 15 hours.

The first officer's recent work schedule involved getting up at 0600 and finishing around 2000 for several days. His logbook entries record many days of short-hop flights, where total flying time for the day exceeded eight hours. The logbook also indicates that his last day of uninterrupted rest away from flying duties occurred on July 13. On the day of the accident, he had indicated to the captain, who was also his employer at Confortair, that he needed to stop flying for a week because he felt he was becoming too tired and worn out. Reportedly, one of the Aviation Québec Labrador pilots was going to replace him for that week. The first officer had made an agreement with the owner of Confortair to fly for Confortair for a couple of months while new pilots were being trained. The first officer was aware that his flying hours exceeded the maximum monthly allowable, but he did not realize he was as many hours over the limit as this report shows. The flying hours on the company's flight manifests matched those in his logbook. As for the quality of his sleep, he reported relaxing completely when he was home.

1.6 Aircraft Information

Manufacturer	Raytheon Beech Aircraft Company
Type and Model	Beech 1900D
Year of Manufacture	1998
Serial Number	UE-347
Certificate of Airworthiness	29 June 1999
Total Airframe Time	373 hours
Engine Type (number of)	Pratt & Whitney PT6A-67D (2)
Propeller/Rotor Type (number of)	Hartzell Inc. HC-E4A-3J with E10950PB blades (2)
Maximum Allowable Take-off Weight	7688 kg
Recommended Fuel Type(s)	Jet A, Jet A-1, Jet B, JP-4, JP-5, JP-8
Fuel Type Used	Jet A

Records indicate that the aircraft was maintained in accordance with the manufacturer's specifications and the applicable regulations. The landing gear was extended before the accident. The flaps were found in the 35° position. The flight data recorder (FDR) information revealed that the engines were functioning normally at the time of impact. The aircraft's weight and centre of gravity were within the prescribed limits. An examination of the instruments at the site revealed that both the captain's and the first officer's altimeters had been set to 29.85 inches of mercury (in Hg), the setting that was passed to the crew by the Port-Menier FSS. The aircraft radios were set to 126.7 MHz. Both airspeed indicators showed the speed at impact to have been in the 152- to 155-knot range. The radar altimeter was set at 100 feet agl.

1.7 Meteorological Information

The Sept-Îles region had been under a fairly stagnant airmass flow and weather pattern for most of August 12. The area forecast for 0800–2000 called for a slow-moving trough of warm air aloft (TROWAL) located over La Grande 4 and extending down to Rivière-du-Loup at 0800, with associated weather dominating most of the province. On the morning of the accident, the lower level of the atmosphere consisted of an extensive stratus cloud deck mixed with towering cumulus and cumulonimbus. The airmass was nearly saturated throughout the isothermal layer. These elements combined to produce widespread areas of low cloud and fog patches.
By 2200, the TROWAL had gone through Sept-Îles. West of the TROWAL, the forecast called for towering cumulus and cumulonimbus clouds to dissipate early in the period and for local fog patches to develop

throughout the period, giving visibilities between ½ sm and 4 sm in fog and mist, with ceilings between 100 and 1000 feet asl.

The latest amended aerodrome forecast received by the crew for Sept-Îles for 1900–0700 called for the following: wind from 090° true at 5 knots, prevailing visibility ½ sm in light drizzle and fog, and vertical visibility of 100 feet. At 1829, the forecast for Sept-Îles was amended using an airman's meteorological advisory (AIRMET), calling for local visibilities and ceilings near zero in on-shore flow. The crew received this information. A wind from the east favoured the development of such an on-shore flow.

At 2000, the Sept-Îles reported weather was ceiling partially obscured, measured at 100 feet agl, visibility 5/8 sm, altimeter setting 29.86 in Hg. The 2100 weather was reported as indefinite ceiling at 300 feet, sky obscured, visibility 3/8 sm in fog, and altimeter setting 29.87 in Hg.

Throughout the afternoon, pilots conducting approaches to runways 13 and 31 reported low ceilings and low visibility. From 1600 to 2357 (the time of the occurrence), records show that commercial operators carried out eight missed approaches at Sept-Îles. At 1720, the first officer landed a Confortair PA-31-350, Flight COF977, after conducting two missed approaches. Before taking off on the first leg of their scheduled flight at 2104, the crew of GIO347 observed that the ceiling was about 200 feet and the visibility was about 1/4 sm. The first officer observed that, on the ground, he could count up to nine runway lights, spaced 200 feet apart. The crew of a Régionnair Twin Otter, which landed at 2059, reported similar weather conditions. Other than these two flights, no other commercial operator successfully landed at Sept-Îles between 1600 and 2357.

The captain had earlier advised the FSS personnel that he would come in for a detailed weather briefing before the departure of GIO347. He instead called the FSS and asked for the actual local conditions and the forecast for Havre-Saint-Pierre, the flight's first destination. A copy of the relevant weather data sheets, consisting of the aerodrome forecasts, hourly weather reports, area forecasts, AIRMETs, winds aloft, and notices to airmen, were obtained by the captain from the Canadian Regional Airline dispatch office at the airport before engine start. The captain did not discuss the weather forecast or the conditions at any of the intended landing points with the first officer.

Nine routine and special weather reports were issued between 2000 and 2400, with reported ceilings between 100 and 200 feet and visibilities of 1/4 sm to 3/8 sm. The Sept-Îles special weather report at 2332, the latest before the accident, was as follows: indefinite ceiling at 200 feet agl, visibility 1/4 sm in fog, wind 160° true at 4 knots, and altimeter setting 29.87 in Hg. The runway visual range (RVR) reading for Runway 09 was reported to be 1600 feet. This is the weather that was reported to the crew after departure from Port-Menier. At the time of the accident, the actual weather conditions had not changed.

1.8 Aids to Navigation

No problems were reported with the aids to navigation or the approach aids within the Sept-Îles area or at the airport for the time of the occurrence. Although the instrument landing system for Runway 09 was serviceable, this precision approach aid could not be used because Runway 09/27 was closed for resurfacing.

1.9 Communications

No communications equipment discrepancies were noted or reported. A review of the radar tape for the flight indicates a primary radar return only, an indication that Mode C (altitude readout function) of the aircraft's transponder was not operating. Nearing Sept-Îles, GIO347 communicated with the FSS on tower frequency 118.1 MHz and advised that the aircraft should be landing in four minutes. GIO347 then transmitted that it was six miles on final. Two minutes later, the FSS operator heard an aircraft calling and attempted to contact GIO347 twice. GIO347 then replied that it was on final and that it would call once on the ground. No further radio transmissions from the aircraft were recorded.

1.10 Aerodrome Information

At the time of the occurrence, the Sept-Îles airfield consisted of three runways in a triangular pattern. (See Appendix B.) Late in 1999, Runway 05/23 was permanently closed and Runway 09/27 was temporarily closed. Runway 13/31 is 6037 feet long by 200 feet wide and is asphalt-covered. The airfield elevation is 180 feet asl. Runway 31 is served by a non-directional beacon (ZV NDB) approach aid. The NDB crossing altitude is set at 900 feet asl (720 feet agl); the MDA is set at 680 feet asl (506 feet agl). No other authorized approach aids serve this runway, as indicated in the *Canada Air Pilot* (CAP 5) approach supplement and in the company's operating certificate. Runway 13 is served by a VOR/DME (very high frequency omnidirectional range / distance-measuring equipment) approach aid. At 540 feet asl (366 feet agl), the MDA limits for this approach are lower than those for Runway 31, but the approach to Runway 13 carries a disadvantage during poor visibility conditions. The VOR facility is north of Runway 13, requiring an offset approach heading of more than 10° from the runway heading. The NDB approach to Runway 31 is depicted in Appendix A. Runway 09/27 is served by an instrument landing system and a LOC(BC) (localizer transmitter (back course)), respectively, but was closed at the time because of ongoing resurfacing work.

1.11 Flight Recorders

The aircraft was equipped with a Loral Fairchild F 1000 FDR. A transcript of the more salient FDR parameters recorded during the approach to Sept-Îles is shown in Appendix C.

The aircraft was equipped with a Loral Fairchild A 100S cockpit voice recorder (CVR). This CVR is a solid-state, continuous loop, four-channel device that records all voice signals transmitted or received by the aircraft crew over the last 30 minutes (or more). The control unit contains TEST and ERASE buttons, an indicating meter, a headset jack, and a microphone amplifier. The erase button is used to erase the entire recording after a routine flight and will only work when the landing gear is down and the weight of the aircraft is on the landing gear. To prevent accidental erasure, a time-delay circuit makes it necessary to hold the erase button down for two seconds to start the erasing process.

The CVR recording of the time the aircraft was on the ground in Port-Menier on the last flight had been erased. Recording began as the aircraft became airborne, and the quality of the recording was good. Analysis of the erase button revealed that this button often stuck when pressed. The erase button was likely sticking while the aircraft was on the ground in Port-Menier. The system's logic allowed the recorder to begin the recording as the wheels came off the ground. This is the first time that this type of malfunction has been noted with this particular type of control unit.

1.12 Wreckage and Impact Information

The aircraft struck the tops of 20- to 50-foot trees 5900 feet from the threshold of Runway 31 in a near wings-level, slightly nose-low attitude, on a heading of 312° magnetic. The impact site is nearly aligned with the extended centreline from Runway 31. The aircraft's composite propellers shattered on impact, and the wingtips were torn off. As the aircraft descended into the trees, it began a slow roll to the left. It struck the ground in a 50° left bank, nose-down attitude, and cartwheeled counterclockwise over the left wing, coming to rest upright and pointing back toward the initial impact point. The aircraft travelled approximately 1100 feet from the initial tree contact to its resting point, 4800 feet short of the runway.

The cockpit was destroyed by the impact forces. It separated from the fuselage immediately behind the cockpit partition and door assembly. The cockpit was crushed by the ground and pushed toward the right wing and engine as the aircraft cartwheeled on top of it. The top of the fuselage above the first row of passenger seats caved in but did not hinder the exit of the two passengers. The rest of the main cabin structure remained largely intact. Parts of the horizontal stabilizer and the rudder were torn off or crushed as the aircraft travelled backwards into trees. The right engine was torn from its mounts and thrown backwards onto the wing. The left engine remained attached.

1.13 Medical Information

An autopsy and toxicological tests were conducted on the captain. The toxicological tests for the presence of common drugs were negative. The autopsy report concluded that the captain died from traumatic shock and multiple injuries.

1.14 Fire

The integrity of the fuel cells was compromised early in the crash sequence, and fuel was sprayed along the crash path. This fuel ignited and scorched the trees and the ground along the last 60% of the impact trail. The right engine and both wings were nearly consumed by the ensuing fire. The left engine suffered less damage. A large hole was burned through the midpart of the right fuselage, and the left midside was singed. The burned trail led the emergency response services (ERS) personnel to the crash site. The fire was rapidly extinguished.

1.15 Survival Aspects

1.15.1 Aircrew and Passengers

The crumpled cockpit area was found lying on its right side, nestled between the fuselage and the right engine. The extensive crushing damage to the cockpit destroyed most of the liveable space surrounding the occupants. The instrument panel was pushed back and down toward the crew. The door panels and door partitioning the cockpit from the cabin area had been crushed and had caved in on the backs of the crew seats during the impact, making exit nearly impossible. The main entrance door to the aircraft is on the left side, immediately behind the cockpit partition. The position of this door after the impact, with the aircraft lying on its right side, prevented the injured first officer from exiting the aircraft through it.

The first officer was wearing his three-point lap belt and his shoulder harness. The captain was only wearing his lap belt. The first officer managed to crawl on his elbows through a hole he found in the partition and dragged himself a few feet away from the wreckage. He remained there until found by ERS personnel. The two passengers, sitting in the left and right seats of row 2, escaped with minor injuries because the cabin structure from row 2 and back remained essentially intact. Fearing an explosion, the passengers undid their seat belts, jumped through the opening, and walked away from the aircraft. They proceeded slowly through the woods, toward the sound of traffic, until they arrived at the highway, approximately 400 metres from the crash site. The visibility in the fog was very poor at the time. An ambulance took them to the Sept-Îles hospital, where a medical examination revealed only minor injuries.

1.15.2 Aircraft

The survival gear was stored in the back of the aircraft. This gear would have been readily accessible if required after the crash, since the cargo door was not damaged and could easily be opened.

1.15.3 Emergency Locator Transmitter

The emergency locator transmitter (ELT) was identified as an Artex Aircraft Supplies Inc., serial number 60930. It had been manufactured in 1998. The ELT switch was found in the ARMED position and activated on impact. The signal was heard by the FSS specialist for four to five seconds, then stopped.

An examination of the ELT at the occurrence site found that the antenna cable was still connected at the connector fitting to the ELT box. The antenna cable is routed through the vertical fin and connects to a fin-type antenna on the top right side of the vertical stabilizer. The antenna was sheared off during the impact sequence. It is likely that the ELT activated on initial impact and that its transmitting range was affected when the antenna was destroyed. The unit was turned off and removed from the aircraft.

1.15.4 Sept-Îles FSS and ERS Actions

As soon as the FSS specialist heard the ELT signal, he attempted to contact GIO347. He then contacted Montréal Area Control Centre's east sector to find out if it was in contact with the aircraft. Upon receiving a negative answer, he immediately called the Sept-Îles ERS to advise of a possible crash at the airport. This call was made approximately three minutes after the aircraft went down. He then contacted the Trenton Rescue Coordination Centre to advise of the situation.

Sept-Îles Airport does not have an ERS unit based at the airfield, although an ERS vehicle is located permanently at the airfield for quick response. Personnel from the town's firefighting unit are trained to perform ERS at the airport. When the FSS alerted the ERS about a missing aircraft, ERS personnel immediately proceeded to the airport by car, staffed the ERS vehicle, and proceeded on instructions from the FSS specialist.

By 0015, ERS personnel, comprising local police and medical personnel in ambulances, were at the airport. The search for the aircraft began along Runway 13/31. The ground search was organized by various teams, which were in darkness and near zero visibility in fog. The Trenton Rescue Coordination Centre and the airport authorities were trying to identify the approximate location of the aircraft from recorded Air Traffic Control radar tapes.

The two passengers were found at approximately 0100. The location of the aircraft was immediately passed to ERS personnel, who arrived at the scene at approximately 0107, having followed the trail of scorched and broken trees on foot. The firetruck easily made a path through the dense, coniferous woods. Medical personnel in ambulances followed and began stabilizing and extracting the aircrew immediately.

1.16 Tests and Research

1.16.1 General

The airspeed indicators, altimeters, transponders, and NDB and GPS control panels were sent to the TSB Engineering Laboratory for analysis and examination. Both altimeters were inspected and found to have been functioning properly at impact. The GPS data were also retrieved. The threshold and alignment data for Runway 31 were the selected (active) waypoint in the aircraft's flight management system.

1.16.2 Encoding Altimeters

The aircraft was equipped with two encoding altimeters. The right-seat altimeter, a Meggitt Inc. altimeter, was verified, and its non-volatile memory was read. The instrument was found to be serviceable and within calibration. The encoder part of the altimeter was also verified during the testing and found to be within specification. The displayed and stored baroset reading showed 29.85 in Hg. The actual barometric pressure for Sept-Îles at the time of the accident was 29.87 in Hg. An altimeter setting of 29.85 in Hg would cause the altimeter to under-read, that is, the true aircraft altitude would be 20 feet above the altitude shown on the instrument.

1.16.3 Transponder

The aircraft was equipped with dual Collins TDR-94/94D transponders and a single control panel. The unit is a Mode S transponder, fully compatible with Mode A and C operation. The function knob on the control panel has four positions: OFF, STBY (standby), ON, and ALT (altitude encoding). The ALT position is the normal mode. The ON position sets the transponder to Mode A operation, with no altitude data in the reply transmission.

The before take-off checklist calls for the transponder to be set to the ON position. When the crew completed the transponder challenge-and-response checklist during the before take-off check, the response to the transponder setting check was "ALT"; however, the transponder function knob was found in the ON position. A review of the radar data for the flight shows that the altitude readout was not captured. A verification of both transponders showed that the Mode C function was serviceable at the time of the accident.

1.17 Organizational and Management Information

1.17.1 Flight and Duty Time Limitations

The directives on flight and duty time limitations in the company's flight operations manual reflected those found in the regulations. Aircrew were required to keep an up-to-date record of their flight and duty times, including rest periods. They were required to advise management when any of these limitations were reached.

1.17.2 Approach Minima Guidance

On 04 January 1999, a controlled-flight-into-terrain accident occurred with this company while the crew was conducting a non-precision approach (LOC/DME Runway 20) in reduced visibility at Saint-Augustin (TSB Report No. A99Q0005). After that occurrence, management verbally briefed its pilots on the requirement to adhere to established ceiling and visibility criteria during approaches in instrument meteorological conditions. A written directive to this effect was not produced for the flight crews' circulation file, nor was the standard operating procedures (SOPs) manual amended. The crew involved in this occurrence were not employees of the company at the time of the previous accident; consequently, they might not have been aware of this briefing, although they knew the regulations concerning approach minima.

1.18 Additional Information

1.18.1 Ground Proximity Warning System (GPWS)

1.18.1.1 GPWS Description

An Allied Signal MK-VI GPWS was installed in this aircraft. The system includes a ground proximity warning computer, an air data computer, various cockpit annunciator lamps and switches (which receive inputs from the aircraft's radio altimeter), a left landing gear downlock switch, a first officer's pitot static system, a glideslope deviation signal, and a cockpit flap control switch. The radio altimeter feeds the GPWS, which generates the warnings and advisories. The ground proximity warning computer processes this information to provide visual and/or aural alerts and warnings to the crew for protection against inadvertent flight into terrain.

The MK-VI GPWS has six modes of operation, which are all accompanied by computer-generated voice messages. Red warning indicators and yellow caution indicators, located in front of each pilot, illuminate according to the type of mode activated. Modes 1 to 4 activate the red warning lights and require specific action by the pilot flying. Mode 5 is reserved for a below-the-glideslope caution during a precision approach and activates the yellow caution light.

Mode 6 does not illuminate any caution or warning light. The modes pertinent to this occurrence, published in the company SOPs, and their associated messages, conditions, and required action are shown in the table below:

MODE	VOICE MESSAGE	CONDITION	ACTION
1	"Sink Rate" followed by "Pull Up" repeatedly	Excessive rate of descent in relation to agl altitude (below 2450 feet).	Level wings and reduce rate of descent until visual and aural alert ceases.
2	"Terrain, Terrain" followed by "Pull Up" heard continuously	Terrain rising excessively fast underneath the aircraft with the gear and the flaps up.	Immediately adjust flight path away from terrain.
6a	"Five hundred"	The aircraft is descending through 500 feet agl.	None. Advisory only.
6b	"Minimums, Minimums"	The aircraft is descending through the DH altitude set on the radio altimeter.	Execute a go-around if the runway is not in sight and the DH or the MDA is confirmed on the pilot's altimeter.

1.18.1.2 Crew Response to GPWS Warnings and Advisories

Modes 1, 2, and 6 activated during the approach to Sept-Îles. The Mode 1 warning sounded when the aircraft was approaching 1000 feet agl. The rate of descent was over 3000 fpm at that time. Mode 2 activated 2.5 seconds later and again 6 seconds after that. The flight operations manual requires that the crew respond immediately to a GPWS Mode 1 to 4 warning, especially during IFR flight or at night, by establishing the maximum climb rate of the aircraft until a safe altitude has been clearly established. The crew did not respond to any of these warnings and advisories.

The manufacturer indicated that the DH altitude was set to 100 feet agl on the altimeter, as recorded on non-volatile memory chips. The GPWS "Minimums, Minimums" audio advisory functioned as designed when the aircraft reached the set altitude. At the MDA or the DH, the pilot flying is required to conduct a missed approach immediately unless advised otherwise by the monitoring pilot. Procedures in the company's flight operations manual require that the monitoring pilot have the runway environment in sight before a "continue" call can be given to the pilot flying. The Board has established that these conditions did not exist when the aircraft reached 100 feet agl. Nevertheless, the captain advised the pilot flying to continue a shallow descent. The time of the GPWS "Minimums, Minimums" activation corresponds to the 100-foot agl and 1.3-nm point on the altitude profile of the FDR's derived data, indicating a good match. The aircraft continued its descent; impact occurred eight seconds later.

1.18.2 Crew Resource Management and Pilot Decision Making

Neither the captain nor the first officer had taken a pilot decision-making (PDM) course with Régionnair or Confortair. The company operations manual states that air operators operating an air service under Section 704 of the *Canadian Aviation Regulations* (CARs) must provide a PDM course during upgrading training and pilot verification checks. PDM training initiates pilots to the decision-making process, the factors influencing human performance (among other things), and ways to counter human errors.

After the accident in Saint-Augustin on 04 January 1999, the Régionnair company operations manager asked Transport Canada (TC) to deliver a CRM course to company pilots. CRM training, more advanced than PDM, encompasses the factors associated with effective crew coordination, such as communication, PDM, and workload management. TC delivered CRM training to company pilots in March, August, and December 1999; however, the occurrence pilots did not receive this training, because neither was employed by Régionnair at the time of the March course. The August course was four days after the accident.

The crew departed Mont-Joli for Port-Menier without obtaining a weather update. A weather update for Sept-Îles was also not obtained while the aircraft was on the ground at Port-Menier with engines running. Upon departing Port-Menier for Sept-Îles, the crew received the latest weather update for their destination. Although the actual and forecasted weather conditions were below limits for all runways at Sept-Îles, the crew elected to continue the flight and conduct an approach. If a missed approach was required due to weather, the plan was to conduct another approach to either Runway 13 or 31, and, if the second approach was unsuccessful as well, to proceed to Mont-Joli.

1.18.3 Regulations Pertaining to Approach and Landing Criteria

CAR 602.129 specifies that, with respect to visibility, approaches are governed by RVR values only. With certain exceptions, pilots are prohibited from completing an instrument approach past the outer marker or final approach fix to a runway served by an RVR if the RVR values measured for that runway are below the established 1200-foot minima for fixed-wing aircraft. Where a runway is not served by an RVR, no regulations prevent aircrew from attempting an approach to that runway. No RVR was available for Runway 31 in Sept-Îles.

CAR 602.128 specifies that landings are governed by published DHs/MDAs. Pilots of aircraft on instrument approaches are prohibited from continuing the final approach descent below DH or descending below MDA, as applicable, unless the required visual reference has been established and maintained to complete a safe landing. When the required visual reference is not established or maintained, a missed approach must be initiated. Pilots must be cautioned that the missed approach segment that provides for obstacle clearance originates at the published missed-approach point (MAP). The published MAP on a precision approach is coincident with the DH. Missed approaches initiated beyond the MAP will not be assured obstacle clearance.

The visual references required by the pilot to continue the approach to a safe landing should be distinctly visible and identifiable to the pilot and should include at least one of the following for the intended runway:

- the runway or runway markings
- the runway threshold or threshold markings
- the touchdown zone or touchdown zone markings
- the approach lights
- the approach slope indicator system
- the runway identification lights
- the threshold and runway end lights
- the touchdown zone light
- the parallel runway edge lights
- the runway centreline lights

Published landing visibilities associated with all instrument approach procedures are advisory only. Their values are indicative of visibilities that, if prevailing at the time of approach, should result in establishing the required visual reference. They are not limiting and are intended to be used by pilots only to judge the probability of a successful landing when compared against available visibility reports at the aerodrome where an instrument approach is being carried out.

1.18.4 Previous Approach Accidents in Marginal Weather Conditions

The Board is reviewing a number of previous approach accidents where bad weather was a contributing factor. Between 01 January 1994 and 30 April 1999, conditions of low visibility and/or low ceiling[2] contributed to 20 accidents in Canada involving fit pilots and airworthy Canadian-registered aircraft conducting IFR approaches or on go-around or landing after an IFR approach. Moreover, the review suggests that a number of pilots regularly conducted user-defined GPS approaches to limits below the minima published in CAP. Some pilots do not recognize the safety value in the criteria used to design approaches. Consequently, they may disregard the established approach procedures in favour of user-defined GPS approaches.

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[2] A low ceiling is less than 100 feet above CAP minima and/or visibility less than ½ sm above that specified in CAP.

1.18.5 Approach Ban Notice of Proposed Amendment by TC

The Canadian aviation community has discussed the need for additional regulatory restrictions for instrument approaches in poor weather for several years. On 16 December 1997, an Air Canada regional jet crashed while attempting to land from an instrument approach at Fredericton Airport, New Brunswick, in poor weather conditions (TSB Report No. A97H0011). On 10 May 1999, the TSB's final report of the Fredericton accident was released. It contained a recommendation (A99-05) that urged TC to examine the apparent inconsistency in the regulations that permit Category I instrument approaches to be conducted in weather conditions worse than those specified for Category II approaches without the benefit of operating requirements and equipment applicable to Category II approaches. The Minister of Transport responded positively to A99-05. The Minister advised that the TC working group would examine regulatory standards for instrument approaches with the view to strengthening the requirements regarding weather minima.

On 09 and 10 September 1999, TC submitted a notice of proposed amendment (NPA 1999-147) on CARs 602.129 and 602.130 for consultation to the members of the General Operating and Flight Rules (GO&FR) Technical Committee (Part VI). The GO&FR Technical Committee was not supportive of the NPA and recommended that TC study the issue further through a system safety review. In response to the recommendations of the GO&FR Technical Committee, the Civil Aviation Regulation Advisory Council (CARAC) directed that a TC/industry study group be established to strengthen the regulations pertaining to the approach ban.

At the beginning of November 1999, the Director General of Civil Aviation and the Executive Directors of the GO&FR and Commercial Air Service Operations (CASO) Technical Committees approved the terms of reference establishing the study group on regulations concerning the approach ban. The study group met on 17 and 18 November 1999 with the objective of making written recommendations accompanied by NPAs to the GO&FR and CASO Technical Committees. The discussions concerned the strengthening of the approach ban that will apply to precision and non-precision approaches and the requirements and standards applicable to air operators and private operators that would permit operations in lower visibility with an equivalent level of safety.

Despite some strong differences of opinion, the study group reached consensus on recommendations concerning the approach ban and on the intent of new regulations and standards. The resulting portion of NPA 2000-01 that applies to aeroplane non-precision approaches states that the visibility is less than the minimum visibility required for a non-precision approach in the following instances:

a. where both RVR "A" and RVR "B" are measured, RVR "A" or RVR "B" for the runway of intended landing is less than 4000 feet;[3]

b. where only RVR "A" or RVR "B" is measured, the RVR is less than 4000 feet;

c. the current take-off visibility is less than 4000 feet; or

d. the reported ground visibility is less than the greater of three-quarters of a statute mile, or one-half of the published visibility for the approach procedure flown, if

   (1) an RVR does not serve the landing runway;

   (2) an RVR report is not available; or

   (3) a current take-off visibility is not available.

On 10 March 2000, the CARAC met and discussed the recommendations made by the joint CARAC / GO&FR and CASO Technical Committees. After reviewing the Technical Committees' recommendations and dissents, the CARAC decided that the proposed approach ban will apply only to CARs Part VII commercial operators. A post-implementation review two years thereafter will assess whether CAR 604 and general aviation operations should be included. The NPA was tabled at the Part VI and Part VII[4] Technical Committees in June 2000 for the information of the members. The Department of Justice has commenced its regulatory review. It takes up to two years to implement new regulations.

[3] RVR "A" is measured from a position adjacent to the runway threshold. RVR "B" is measured from a position adjacent to the runway midpoint.

[4] Part VI, Subpart 4 applies to the operation of a Canadian aircraft used to transport passengers, where the aircraft is a turbine-powered pressurized aeroplane or a large aeroplane, and is not required to be operated under Subpart 6 of Part IV or under Part VII. Part VII applies to all commercial operators operating in Canada.

1.18.6 Aircraft's Approach Profile

During the descent into Sept-Îles from cruising altitude, the aircraft's flight profile was high and fast in relation to its range to the ZV NDB. The captain felt that a shuttle-type manoeuvre such as a 360° turn might provide for a more stabilized approach beyond the beacon and expressed his concern. The pilot flying replied that this should not cause a problem, and the captain allowed the flight to continue. At 1 nm from the NDB, the aircraft's rate of descent was still approximately 3000 fpm. The airspeed was 200 knots, and the flaps and the landing gear were up. The approach flap was selected as the aircraft arrived at the NDB, but the pilot flying had to raise the nose of the aircraft to slow down to the landing gear limiting speed. The aircraft's rate of descent between the NDB and 2.5 nm from the threshold varied between 1000 fpm and 1500 fpm, after which it stabilized at 850 fpm until impact. The indicated airspeed decreased from 200 knots at the NDB to approximately 137 knots at 2 nm from the threshold, then increased steadily to reach 153 knots at impact.

The company's flight operations manual states that the aircraft shall be configured in the following manner by the final approach fix (the NDB) during NDB approaches: landing gear and flaps down and airspeed V_{ref} + 10 knots. The calculated V_{ref} + 10 knots airspeed for the weight of the aircraft during the approach to Sept-Îles with full flaps was 119 knots. A missed approach must be initiated if the aircraft is not stabilized, with those parameters met, by the final approach fix.

1.18.7 Flight and Duty Time Limitations and Calculations

1.18.7.1 TC Limitations

The regulations pertaining to commercial crew flight and duty times are found in CARs 700.14 to 700.19. They state that every air operator shall establish a system that monitors the flight time, the flight duty time, and the rest periods of each of its flight crew members and shall include in its company operations manual the details of that system. The regulations require that where a person becomes aware that an assignment by an air operator to act as a flight crew member on a flight would result in exceeding the maximum flight time or the maximum flight duty time, the person shall so notify the air operator.

No air operator shall assign a flight crew member for flight time, and no flight crew member shall accept such an assignment, if the flight crew member's total flight time in all flights conducted by the flight crew member will, as a result, exceed one of the following:

- 1200 hours in any 365 consecutive days
- 300 hours in any 90 consecutive days
- 120 hours in any 30 consecutive days or, for a flight crew member on call, 100 hours in any 30 consecutive days

No air operator shall assign a flight crew member for flight duty time, and no flight crew member shall accept such an assignment, if the flight crew member's flight duty time will, as a result, exceed 14 consecutive hours in any 24 consecutive hours.

1.18.7.2 Captain's Flight and Duty Times

The captain flew 127 hours in the last 30 days and 337 hours in the last 90 days. A monthly or quarterly flight time extension request for the captain could not be found in either his or TC's files. On the day of the accident, he had been on duty, first at his own company and then at Régionnair, for 16 hours. His logbook records indicate that from July 28, he flew every day for one or the other company (and sometimes for both on the same day) except for August 4, 5, and 10. His total flying hours for those 11 days were 73.5 hours, an average of 6.68 hours per day. It could not be determined how much time he spent daily performing administrative or operational tasks at his own company when he was not flying. The captain was required to report his Confortair flying times monthly to the Régionnair operations officer for tracking. His total flying times for both companies, from May 1 to July 21, were on record at Régionnair. Flying times after that date had not been reported.

1.18.7.3 First Officer's Flight and Duty Times

The first officer flew 181 hours in the last 30 days and 368 hours in the last 90 days. Like the captain, a monthly or quarterly flight time extension request for him could not be found in either his or TC's files. On the day of the accident, he had been on duty, first at Confortair and then at Régionnair, for 18 hours. The first officer's logbook indicates that he had been on duty and flew for one or the other company every day since July 14, except for August 1. His total flying times for both companies, from June 6 to July 31, were on record at Régionnair. Total flying times for August had not been reported. Neither the regulator nor Régionnair was aware that both pilots were exceeding their flight and duty time limitations.

1.18.7.4 Pilot Fatigue

Researchers at the Defence and Civil Institute of Environmental Medicine found that after 18 hours awake, people showed a 30% decrement in performance on cognitive and vigilance tasks. After 48 hours, the impairment averaged 60%. Researchers at the Centre for Sleep Research at the University of South Australia found that after 18 hours without sleep, students performed as poorly on performance tests as they had with a blood alcohol concentration of 0.05%. After 24 hours without sleep, their performance decreased to that of a person with a blood alcohol concentration of 0.096%.[5]

[5] Research conducted by Dr. Drew Dawson of the Centre for Sleep Research, University of South Australia, and reported in *The NSF Connection*, 4, 1, 1997, p. 1.

As a commuter operation, conducted under Section 704 of the CARs, the company had to provide either 36 consecutive hours free from duty requirements within each 7 consecutive days or 3 consecutive calendar days within each 17 consecutive days. Neither crew member was provided with this time off specified in CAR 700.12(a). Operationally, it is important that recovery periods be scheduled to provide an opportunity to acquire recovery sleep and to re-establish normal levels of performance and alertness. Frequent recovery periods are important. More frequent recovery periods reduce cumulative fatigue more effectively than less frequent ones. For example, weekly recovery periods afford a higher likelihood of relieving acute and cumulative fatigue than monthly recovery periods.[6]

Fatigue can lead to forgetting or ignoring normal checks or procedures and reversion to old habits. Fatigue can also reduce attention, causing one to overlook or misplace sequential task elements, become preoccupied with a single task, and be less vigilant. When alertness is impaired, one may focus on a minor problem (even when there is risk of a major problem), fail to anticipate danger, and display automatic behaviour syndrome. Problem solving can also be affected and may lead to inappropriate actions.

1.18.8 GPS Unit

1.18.8.1 GPS Description

The GPS is a satellite-based, radio-navigation system. TC requires that GPS units used as the primary means of navigation for IFR flight meet Technical Standard Order (TSO) C-129.

The GPS receiver verifies the integrity (usability) of the signals received from the GPS constellation through receiver autonomous integrity monitoring (RAIM) to determine if a satellite is providing corrupted information. At least one satellite, in addition to those required for navigation, must be in view for the receiver to perform the RAIM function; thus, RAIM needs a minimum of five satellites in view, or four satellites and a barometric altimeter (baro-aiding), to detect an integrity anomaly.

RAIM messages vary somewhat between receivers; however, there are generally two types. One type indicates that too few satellites are available to provide RAIM. Another type indicates that the RAIM has detected a potential error that exceeds the limit for the current phase of flight. Without RAIM capability, the pilot has no assurance of the accuracy of the GPS position.

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6 D.F. Dinges, R.C. Graeber, M.R. Rosekind, A. Samei, and H.M. Wegmann, *Principles and Guidelines for Duty and Rest Scheduling in Commercial Aviation*, NASA Technical Memorandum 110404, 1996.

GPS receivers that meet the standard automatically adjust the course indicator sensitivity so that full needle deflection equates to 5 nm in the en route area, 1 nm in the terminal area (an area within 30 nm of an airport during approach or overshoot), and 0.3 nm in the final approach area. The GPS equipment must present an alert when the integrity of the receiver does not assure navigation precise enough to allow the equipment to keep the aircraft within each sensitivity area. Also, the equipment must present a RAIM alert if it receives fewer than five satellites, regardless of the phase of flight.

As a GPS-equipped aircraft flies toward the airport, following an approach that has been retrieved from the GPS database, the course indicator sensitivity automatically changes as the aircraft crosses sensitivity boundaries. When the aircraft is flying to a manually entered waypoint, the receiver will remain in the en route (5 nm) mode. In most GPS receivers, the pilot can force the sensitivity of the course indication; however, this will not affect the triggers for the RAIM alerts. In this situation, there will be alerts only if signal degradation exceeds 5 nm or if there are fewer than five satellites being received.

Approved stand-alone GPS approaches are based on surveyed runway reference points, which are usually certified by accredited surveyors. The reference points are used as anchor-points for the whole transition, comprising about six waypoints. The paths between two consecutive waypoints are called segments, for which particular requirements, such as minimum altitudes, are prescribed.

The only approved way to use a GPS as the primary approach aid is to fly an approach (waypoints, positions, and sequences) retrieved from a pre-loaded, current, tamper-proof database. The equipment will not present the approach if any modifications to the approach are attempted. Before flying the approach, pilots must verify the positions of the waypoints against the hard-copy values in CAP.

1.18.8.2 GPS Overlay Approaches

GPS overlays are traditional approaches (NDB, VOR [with or without DME]) flown using GPS guidance from an IFR-certified receiver. Because of the greater accuracy from the GPS receivers, pilots can more effectively carry on the approach and are provided with a better air picture resulting from the distance-to-go available and, in many cases, the map display from the receiver. Safety is enhanced by the process. The approach minima for GPS overlays are the same as for the traditional approaches on which they are overlaid. TC requires that air carriers carry the same equipment and have the same training to fly GPS overlays as for stand-alone GPS approaches.

The approach flown at Sept-Îles by the crew was not authorized to be flown using the GPS. Had this approach been published as an authorized GPS overlay, the minima would have been the same as for the NDB, because of the obstacle represented by the antenna 3 nm on approach.

1.18.8.3 Aircraft's GPS Installation

The aircraft was equipped with dual Bendix/King KLN 90B GPS receivers. They were removed from the occurrence site and forwarded to the manufacturer's facility for data retrieval. The last recorded waypoint corresponded to Runway 31 threshold coordinates. The magnetic bearing and distance to this waypoint were 312° at 1 nm, which corresponded to the position of the crash site.

The GPS installation for this aircraft initially conformed to TSO C-129. However, the system software version in the accident aircraft was no longer current, because the required 14 July 1999 update had not been entered in the database. At the time of the accident, the GPS installation did not fully meet the requirements of the TSO for GPS.

1.18.8.4 Use of the GPS for Approaches

Navigation using the GPS is becoming more common. Manufacturers of new aircraft are incorporating GPS navigation sensors into their flight management systems. Owners of existing aircraft frequently install stand-alone GPS systems or incorporate GPS sensors into integrated navigation or flight management systems. A similar trend is expected in the future for GPS/WAAS (wide area augmentation system) equipment.

Nav Canada is tasked with developing public GPS approaches to Canadian airfields and aerodromes. At airfields and aerodromes with limited or non-existent approach aids, there are the added demands of airlines and pilots to provide them with GPS approaches and limits similar to those of current precision approach aids.

Because of the risk of mis-entry, pilots are not permitted to manually input waypoints to be used in any phase of flight under IFR.

Some aircrew operating in the Basse Côte-Nord (and elsewhere) have routinely used the GPS to conduct IFR approaches at aerodromes to descent minima that are below those of published approaches established for the runway in use. The method, whether the aerodrome is served by another type of approach aid or not, is generally as follows: aircrews first enter the threshold and runway heading coordinates into the GPS, then fly the approach under visual conditions to confirm alignment and to plot what they consider safe descent altitudes from the threshold. Once the data have been validated, aircrew use those coordinates to fly to the runway, often under weather conditions near or even below those requiring normal approach aids. This was the procedure used by this crew. A data sheet printout containing latitude and longitude threshold coordinates and runway headings for all the runways of the aerodromes served by the company was found in the crew's documents at the site. During the day of the accident, the reported ceiling and visibility generally remained below the MDA limits established for any approach to the airport. Records show that a number of aircraft took off and landed in those conditions, including a Régionnair Twin Otter.

1.19 Company Management

Régionnair, which has held an operating certificate since September 1992, operates a charter air service and a scheduled air service under Sections 703 and 704 of the CARs. The operation of GIO347 was subject to Section 704, Commuter Operations. Régionnair mainly serves the Basse Côte-Nord coastal communities. Besides the main base at Chevery, Quebec, Régionnair has seven secondary bases. At the time of the occurrence, the company operated five aircraft: two Beech 1900's, one Cessna 208 Caravan, one Beech 90 King Air, and one de Havilland DH6 Twin Otter.

As a result of a regulatory inspection on 19 and 20 January 1999—after Régionnair's accident at Saint-Augustin on 04 January 1999, involving the company's other Beech 1900—TC revoked the pilot-in-command's right to serve as chief pilot and revoked the president's right to serve as operations manager. TC felt that the pilot-in-command had not exercised good supervision over the procedures used by the crew members and that the operations manager had not ensured the safety of air operations or exercised control over operations and the aircraft operating standards used. TC restored the company president's right to serve as operations manager after he submitted a corrective action plan.

On 13 August 1999, after this accident, TC revoked Régionnair's operating certificate because the company had had two aircraft accidents in similar weather conditions within one year and there was a perceived lack of control with the flight operations of the company. On 18 August 1999, the operating certificate was reinstated with the proviso that all aircrew undertake a TC CRM course and that the company replace the operations manager, put in place a flight safety program, and promptly correct any flight-safety deficiencies uncovered by the regulatory audit.

2.0 Analysis

2.1 General

No aircraft technical or structural system anomalies affected the safety of the occurrence flight. The aircraft's flight management system operated as designed and did not contribute to the accident. Nothing indicates that there was an emergency or that the aircraft exhibited any problems before the crash, and the crew members did not mention any malfunction during the flight. The response to the accident by the ERS and the airport authorities was well coordinated and timely, given the circumstances.

The approach was not conducted in a safe manner, nor was it conducted in accordance with existing regulations and company SOPs. As well, the aircraft was never fully stabilized on the descent profile, with wildly varying descent rates and aircraft speeds. The analysis will concentrate on the following:

- the safety issues involved in the crew's decision to conduct a user-defined GPS approach below the limits specified for that runway in CAP;
- TC regulations pertaining to low-ceiling/low-visibility approaches;
- the conduct of an approach while the flight path of the aircraft is not stabilized;
- the crew's disregard of the GPWS warnings; and
- crew fatigue caused by excessive flight and duty time.

2.2 Conduct of User-Defined GPS Approaches

As pilots gain experience with the use of a GPS, they realize that this navigation system is usually more accurate than other navigation systems, such as VORs and NDBs. Furthermore, GPS reception is not affected by the aircraft's altitude or distance from the transmitting station. Some pilots have developed their own series of runway threshold coordinates and inbound headings for the aerodromes to which they routinely fly. They have repeatedly confirmed during visual approaches that the GPS provides an accurate track and distance relative to a runway. They have thus gained a high confidence in the GPS capabilities. As a result, some pilots conduct user-defined GPS approaches down to minima close to, or below, those of current precision approaches. However, this practice has many inherent dangers:

- In designing approaches, crews manually input waypoint coordinates and, in doing so, may inadvertently enter incorrect coordinates for the intended waypoint.
- The GPS remains in navigation (en route) mode, with the attendant 5-nm sensitivity, unless manually forced into the approach mode.
- In the "forced approach" mode of operation, although the course sensitivity is changed, the RAIM alerts will be based on the en route sensitivity.
- The criteria for designing approaches and their descent limits are based on extensive research and specific tolerances that enable aircrew to conduct approaches safely. Any deviation from approved procedures will reduce this safety margin.

Although the aircraft's GPS equipment initially met the TSO C-129 requirements, the required 14 July 1999 update had not been entered in the database. Moreover, the company had not provided the crew with the mandated TC training in the use of the GPS for en route navigation and approaches. The crew were, therefore, not qualified or authorized to use it as a primary means of navigation. Finally, selection of a user-defined waypoint as a reference to conduct an ad hoc GPS approach bypassed all the safety criteria considered in the design of stand-alone or overlay GPS approaches.

Nav Canada is continually developing new GPS stand-alone and overlay approaches to Canadian airports and aerodromes. Until the implementation of WAAS and/or LAAS (local area augmentation system), GPS approach limits to aerodromes will not be appreciably lower than those of existing straight-in, non-precision approach aids. This said, the reliability of the GPS to provide a stable and precise approach azimuth to an aerodrome has clearly been demonstrated. Moreover, existing approach limits for those aerodromes at which only a circling approach is authorized are generally higher than those where straight-in approaches are conducted. Timely implementation of GPS approaches to remote aerodromes that have high MDAs would lower those MDAs and allow aircrews to better serve remote communities, in a safe environment.

2.3 Approach Decision and Minima Selected by Crew

Runway 31 is not served by an RVR, so no regulations were in place to prevent an approach to that runway, regardless of the ceiling and visibility conditions. In view of the reported weather conditions at destination, the crew knew that an NDB approach to Runway 31, respecting the limitations in CAP, would not provide them with the required ceiling and visibility conditions to land the aircraft. The crew, therefore, decided to conduct a user-defined GPS approach to an altitude lower than the minima established for the NDB approach. Once that decision was made, the captain performed the required GPS data inputs and discussed the altitude versus distances that the pilot flying should aim for from the ZV NDB to the threshold. It was decided to aim for 300 feet agl at 3 nm and 100 feet agl at 1 nm, followed by a shallow descent until the approach lights were seen.

The crew did not brief for the NDB approach as required by company SOPs. Rather, an ad hoc procedure, which included many flight parameter changes, was devised when the pilot flying was required to concentrate on flying the aircraft.

2.4 Breach of Minimum Descent Altitude Factors

GPS is a remarkable navigation and approach aid system addition. However, the accuracy of any approach aid system is but one of the factors in the descent minima equation. The system's status warning capability, the runway centreline and approach lighting, sequencing strobe lights, and obstacle clearance, among other factors, also affect descent minima imposed on approaches.

The crew planned and flew well below a safe height, aware that they would not see the runway environment until below minima. When the Port-Menier FSS reported the Sept-Îles weather to the crew as ceiling 200 feet and visibility 1/4 sm, the captain reasoned that it was only the visibility that was marginal, but that it should not prevent a successful landing. The decision to descend below the approach minimum was, therefore, made at that moment and accepted without question by the first officer. That decision is troubling because aviation regulations, which were taken so lightly in this occurrence, are made to ensure the safety of persons, property, and the environment.

The captain was experienced with the aircraft and with the aerodromes and the airports within the company's radius of operations. There is no doubt that he had a high confidence in his flying abilities. Reportedly, the practice of conducting user-defined GPS approaches and limits was common within this and other companies until Régionnair's accident at Saint-Augustin on 04 January 1999. After that accident, Régionnair's president gave specific verbal instructions to all his aircrew to respect all descent minima. The crew involved in the Sept-Îles occurrence did not work for the company when the briefing was given. They were not briefed on this point when they were hired in the spring of 1999 and might have felt that the practice of descending below MDAs/DHs was acceptable.

Several other factors might have influenced the crew's decision to descend below authorized minima without having visual contact with the ground or the runway environment. It is useful to recognize the kinds of factors that can play a role in similar situations. Although there was reportedly no pressure at this company to breach descent minima, this practice was perceived as still being common. This perception might put additional pressure on the crew to try to land despite the weather. Passengers' loyalties often shift to the company that will provide the most regular service to their destination because they are not in a position to assess the safety aspects of the operation. Business revenue suffers when a competitor is perceived as being able to provide a better service. Commuter and air taxi operators regularly and routinely serve many communities for which passenger transport and cargo air service is critical. Aircrew feel that they are a vital link to these communities and, thus, may put additional pressure on themselves to provide the service if at all possible. Fatigue might have impaired crew performance. Regulations allowed the crew to carry out the approach at that runway despite the weather conditions; the runway did not have an RVR, so no approach ban was in effect. It was not possible to determine which, if any, of the above hypotheses reflect factors that played a role in this accident.

2.5 Residual Risk with the Proposed Approach Ban

The proposed approach ban is applicable to all commercial operators. By preventing the crew from conducting an approach in very poor visibility conditions, the ban will reduce the risk inherent when conducting approaches in marginal weather where no RVR is available. However, the regulations may not be changed for some time. In the meantime, commercial operators will continue to legally conduct approaches in visibility conditions lower than those contained in the NPA. Because enough information suggests that a number of aircrews continue to "push" the ceiling and visibility criteria, the risk remains high that these accidents will continue to occur under the present regulations: timely implementation of the approach ban is required.

Of the 20 accidents the TSB is reviewing, eight (40%) occurred when the visibility was at or above the recommended CAP minima, but the cloud ceiling was below the approach MDA. In addition to these eight, two more recent accidents have occurred, involving similar circumstances. In February 2000, an air taxi operations aircraft carrying six passengers crashed while returning to land, after a missed NDB approach to the aerodrome (TSB Report No. A00H0001). The MDA for this approach was 695 feet, and the recommended visibility was 1 3/4 sm. The reported ceiling was 300 feet, and visibility was 3 sm. In June 2000, a commercial aircraft crashed while circling to land after attempting two NDB approaches to an aerodrome at night (TSB Report No. A00O0111). The MDA for this approach was 572 feet, and recommended visibility was 1 3/4 sm. The automatic weather observation systems reported ceiling at the time was varying between 400 feet at the time of the first approach and 300 feet at the time of the crash. The visibility remained steady at 9 sm in fog. In both these instances, the proposed approach ban would not have prevented the crews from conducting these approaches because the ban is not based on the height of the ceiling.

The NPA does not address the ceiling issue, other than requiring aircrew to respect MDA/DH limits. This report has demonstrated that pilots do not always adhere to MDA/DH limits. While it is acknowledged that visibility is a factor in more accidents, aircrew are also at increased risk when conducting non-precision approaches in reported ceiling conditions below the minima stated for the approach. With the approach ban proposal in mind, this risk will continue to exist when the reported visibility is at or close to the proposed limits stated in the NPA, particularly during night approaches to aerodromes that have few or no runway environment clues available to the aircrew. Unless measures are taken to address this ceiling issue with respect to non-precision approaches, a risk to life and property will remain.

2.6 Unstabilized Approach

The investigation established that the pilot flying did not attain a stabilized flight path for the approach. When given the suggestion that a shuttle-type manoeuvre might be desirable, he indicated that this would not be necessary, and the captain accepted the decision. The captain's responsibilities during the approach were to monitor the flight path of the aircraft and to look for visual cues that would allow a safe landing. However, because the approach was unstable, he devoted most of his attention to monitoring the aircraft approach parameters and to coaching the first officer. Nevertheless, a decision to continue the unstabilized descent until the runway environment was sighted, in view of the known weather conditions at the airfield, removed all the safety margins that are built into any approved instrument approach procedure.

The crew had several opportunities to abort the approach. The first came when the captain became concerned that the aircraft was too fast and high, too close in. Secondly, an unstabilized flight path by the final approach fix should have resulted in an automatic overshoot decision by the pilot flying or command from the captain. A PDM/CRM course might have provided the captain with the tools to discuss his concerns more positively and to take appropriate action. Additionally, fatigue and the desire to terminate the flight for a much desired rest were likely factors in the crew's decision-making process.

2.6.1 Disregard for GPWS Warnings

The GPWS provided warning alarms on several occasions during the approach. When it became evident that the aircraft was approaching the airport from too high an altitude for the desired approach, the first officer, rather than undertaking a shuttle manoeuvre, increased the aircraft's rate of descent to obtain the desired altitude. The increased rate of descent triggered the Mode 1 alarm (sink rate) of the GPWS. Neither crew member reacted to the alarm. Because of the unstabilized approach, the Mode 2 alarm activated twice, again with no response from the crew. At 100 feet agl, the altitude selected by the crew on the radio altimeter, the Mode 6 alarm sounded. The crew, confident in their GPS position, elected to slowly continue their descent below 100 feet agl until acquiring the runway environment. The crew's decisions and actions effectively rendered the GPWS functionally useless.

2.7 Pilot Fatigue

While it was not possible to obtain a 72-hour work/rest/sleep history leading up to the occurrence, information suggests that the crew was fatigued. The captain had been on duty for 16 hours and the first officer 18 hours on the day of the occurrence.

Both crew members were flying for two companies. Over the last 30 days, the first officer had only one day of rest and worked an average of 14 hours a day, including 6 hours a day flying. He had made arrangements to be replaced for a week because he was becoming too tired and worn out to continue flying. The first officer was probably suffering from chronic fatigue. Further, the 30-day and the 90-day duty times of both crew members exceeded the legal maxima identified by TC.

The crew likely underestimated their tiredness. It has been demonstrated that people do not reliably estimate their alertness and performance: the crew might have felt comfortable in proceeding with their flight even though they would have exceeded their maximum allowable daily flight duty time. Based on what is known about fatigue and its effects, this crew was probably operating the aircraft while fatigued. Thus, they were more likely to make handling and communications mistakes and to be less attentive to details. They would have been less careful than usual, and their decision-making ability would have been impaired.

2.7.1 Flight and Duty Time Monitoring

The CARs and the company's SOPs state clearly the regulations concerning flight and duty time limitations. Both documents require crews to take appropriate action to ensure that those limitations are respected, unless extensions have been granted. These regulations do not absolve the operator or the regulator from their responsibility to verify that aircrew respect the limitations.

The CARs also state that every air operator shall establish a system that monitors the flight time, the flight duty time, and the rest periods of each of its flight crew members and shall include in its company operations manual the details of that system. Both pilots were required to track their flight time at the other company monthly. This once-a-month method made it impossible for the operations officer to continually monitor their total flight time progress. A more continuous monitoring would have prevented the individuals from exceeding the monthly/quarterly flying times. Daily flight duty times performed at the other company were not being tracked. Consequently, Régionnair had no record that the first officer had been working for 30 days with only 1 day of rest.

The following TSB Engineering Laboratory Report was completed:

LP 87/99—Flight Recorder and Instrument Analysis

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

3.0 Conclusions

3.1 Findings as to Causes and Contributing Factors

1. The pilot flying did not establish a maximum performance climb profile, although required by the company's standard operating procedures (SOPs), when the ground proximity warning system (GPWS) "Terrain, Terrain" warning sounded during the descent, in cloud, to the non-directional beacon (NDB).

2. The pilot flying did not fly a stabilized approach, although required by the company's SOPs. The crew did not carry out a go-around when it was clear that the approach was not stabilized.

3. The crew descended the aircraft well below safe minimum altitude while in instrument meteorological conditions.

4. Throughout the approach, even at 100 feet above ground level (agl), the captain asked the pilot flying to continue the descent without having established any visual contact with the runway environment.

5. After the GPWS "Minimums, Minimums" voice activation at 100 feet agl, the aircraft's rate of descent continued at 850 feet per minute until impact.

6. The crew planned and conducted, in cloud and low visibility, a user-defined global positioning system approach to Runway 31, contrary to regulations and safe practices.

3.2 Findings as to Risk

1. At the time of the approach, the reported ceiling and visibility were well below the minima published on the approach chart.

2. Because the runway was not equipped with a reporting runway visual range system, flying the NDB approach was allowable under the existing regulations.

3. The crew did not follow company SOPs for the approach and missed-approach briefings.

4. Both crew members had surpassed their maximum monthly and quarterly flight times and maximum daily flight duty times. They were thus at increased risk of fatigue, which leads to judgement and performance errors.

5. The first officer likely suffered from chronic fatigue, having worked an average of 14 hours a day for the last 30 days, with only 1 day of rest.

6. Transport Canada was not aware that the company's pilots were exceeding the flight and duty times.

7. The company operations manager did not effectively supervise the flight and duty times of company pilots.

8. The captain had not received the mandatory training in pilot decision making or crew resource management.

3.3 *Other Findings*

1. The emergency locator transmitter activated on initial impact but ceased to transmit shortly thereafter when its antenna cable was severed.

4.0 Safety Action

4.1 Safety Action Taken

4.1.1 Transport Canada

On 13 August 1999, Transport Canada (TC) conducted a post-occurrence audit of Régionnair Inc. The findings of this inspection, primarily regarding training shortcomings and the lack of qualified management personnel, resulted in the suspension of the company's air operator certificate effective that date. The company's response to the identified shortcomings resulted in the reinstatement of the air operator certificate on 18 August 1999.

TC, Safety Systems, gave three crew resource management courses specifically for the company in March, August, and December 1999. Twenty-four Régionnair pilots were trained and qualified. An additional course was offered to all pilots on 15 January 2000.

Subsequent to the TSB's safety recommendation (A96-11) in 1996 to raise commercial operators' awareness of the risks associated with flight operations in marginal visual flight conditions, many of TC's national aviation safety promotional efforts, safety awareness programs, and regional education programs have focused on the issue of weather.

A combined TC/industry study group is reviewing the safety data and the issues surrounding approaches in poor weather. Regulatory recommendations concerning approach bans, in the form of a notice of proposed amendment, were submitted to the General Operating and Flight Rules Technical Committee of TC in December 1999.

TC has issued special aviation notices and aeronautical information circulars and made entries in *Aeronautical Information Publication* concerning global positioning system (GPS) use. TC has also published a number of articles in the *Aviation Safety Letter* and *Aviation Safety Vortex* newsletters addressing the operating limitations and safe use of GPS. *Aviation Safety Letter,* issue 4/2000, contains an article titled "Dangers of Flying Home-made GPS Approaches". The author warns pilots that this practice "is like playing Russian roulette with the lives of all on board".

TC, Commercial and Business Aviation, is drafting a commercial and business aviation advisory circular (CBAAC) to emphasize to operators the importance of maintaining records of pilot flight duty hours and flight hours. The CBAAC will emphasize the importance and various parties' responsibilities regarding the recording of duty and flight hours of pilots who fly for more than one operator.

4.1.2 *Régionnair*

Since the occurrence, Régionnair appointed a new director of flight operations and established a safety program. The newly selected safety officer attended a safety officers' course in October 2000. Both persons met the TC requirements for the positions.

4.1.3 *Nav Canada*

The Nav Canada Sat Nav office is working with TC and the US Federal Aviation Administration to phase in full use of GPS for all phases of flight in Canada. The *Safety of Air Taxi Operations (SATOPS) Final Report* recommends 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.

4.2 *Safety Action Required*

4.2.1 *Low Visibility and Low Ceiling Approaches*

The need for additional regulatory restrictions for instrument approaches in poor weather has been discussed in Canada for several years, because of the number of accidents that occur during the approach and landing phase. From January 1994 to December 2001, the Board has investigated 24 such accidents where low visibilities and/or ceilings likely contributed to the accident. (See Appendix D. Some of these investigations are ongoing.) These accidents resulted in 34 fatalities and 28 serious injuries, not counting the loss of property and damage to the environment. In September 1999, TC initiated action to implement new approach ban regulations based on visibility. These regulations should reduce the likelihood of accidents during instrument approaches in low visibility conditions. This process has been ongoing for two years now; however, its timely implementation has been delayed because of some resistance. Until these regulations are promulgated, there will continue to be inadequate defenses against the risks associated with pilots descending below the decision height / minimum descent altitude (DH/MDA) in an attempt to land in visibility conditions that are unsafe. Consequently, controlled-flight-into-terrain accidents on approach that result in loss of life and damage to property have continued to occur and will likely continue to occur. The Board therefore recommends that:

> The Department of Transport expedite the approach ban regulations prohibiting pilots from conducting approaches in visibility conditions that are not adequate for the approach to be conducted safely.

A02-01

Most pilots adhere to regulations, rules, and standard operating procedures because it is good airmanship to do so. Education directed at pilots and others in the air industry attempts to instill safety cultures that will result in safer flight. TC actively promotes good airmanship and attempts to educate persons about safe practices and the risks in disregarding safe practices. However, for whatever reason—operational pressures, pride, commitment to the job—some pilots continue to conduct approaches in weather conditions where there is little chance of completing a safe landing. Unfortunately, many of these approaches result in accidents, injuries, and deaths directly attributable to the weather conditions and the pilots' decisions. Airmanship and education are evidently not effective in curtailing accidents of this type. Such accidents will continue to occur unless further action is taken. The Board believes that an enforceable, regulatory barrier is required.

The proposed approach ban addresses the visibility issue to a large extent but does not address the ceiling issue. Although regulations exist to prohibit pilots from descending below the applicable DH/MDA descent altitude for their approach, these regulations are not enforceable. In recent years, the Board has investigated a number of accidents where the visibility was reasonable, but the ceiling was below the limits stated in *Canada Air Pilot* for the particular approach flown. (See Appendix D.) Therefore, the Board recommends that:

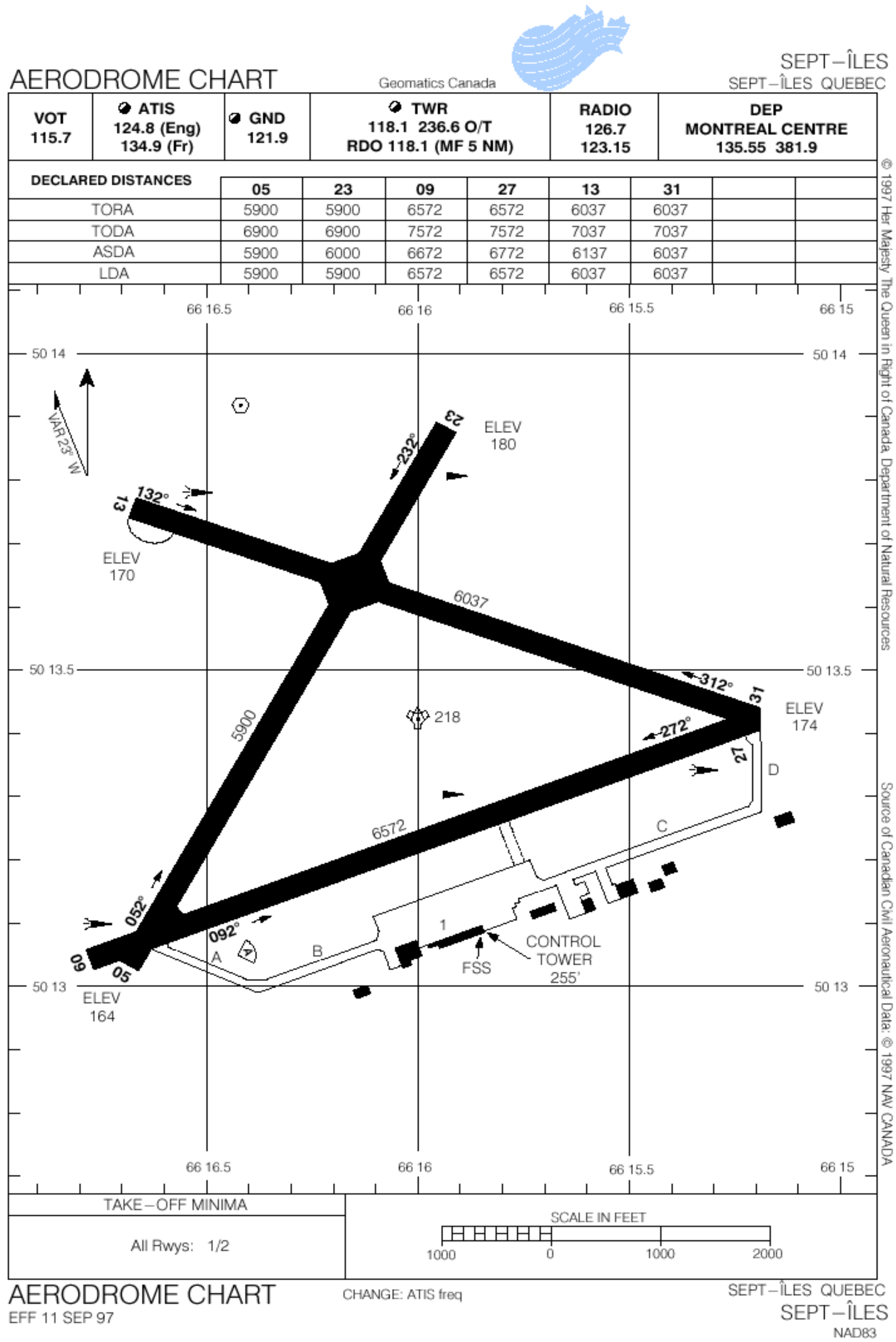
> The Department of Transport take immediate action to implement regulations restricting pilots from conducting approaches where the ceiling does not provide an adequate safety margin for the approach or landing.

A02-02

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 10 January 2002.

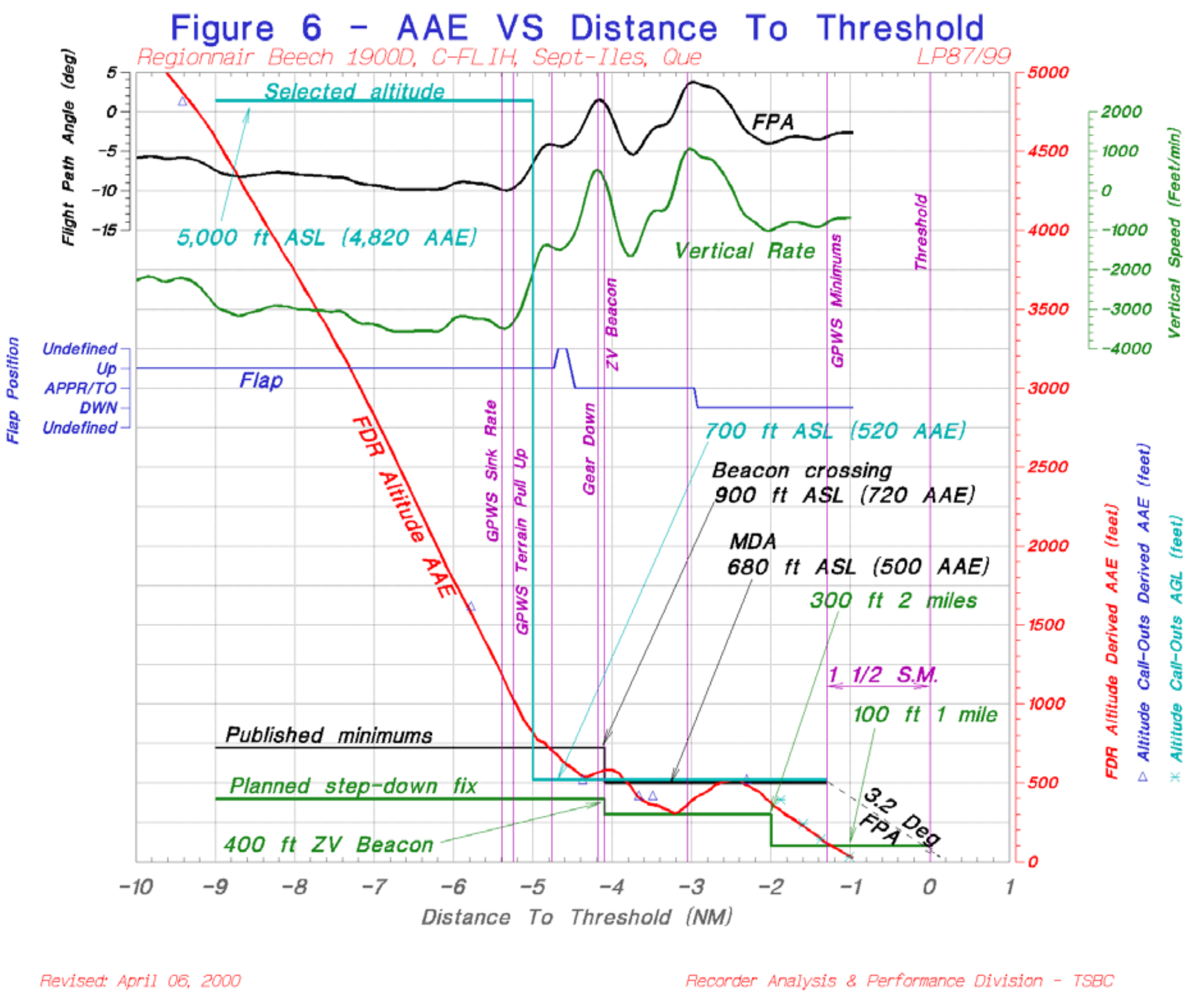
Appendix A—NDB Runway 31

Appendix B—Airport Diagram



DECLARED DISTANCES	05	23	09	27	13	31
TORA	5900	5900	6572	6572	6037	6037
TODA	6900	6900	7572	7572	7037	7037
ASDA	5900	6000	6672	6772	6137	6037
LDA	5900	5900	6572	6572	6037	6037

Appendix C—Flight Data Recorder Data



Appendix D—Weather-Related Accident Statistics

Accidents in Canada between 1 Jan 1994 and 12 Dec 2001 during conditions of low visibility and/or low ceilings in which these conditions likely contributed to the accident.

	Occurrence	Date	Type Of Approach	DH/MDA	Actual Ceiling (feet agl)	CAP Visibility	Actual Visibility	Reported visibility available?	Fata-lities	Serious Injuries
1	A99Q0151	12-Aug-99	NDB 31	506 agl	200	1 1/2	1/4 in fog	yes	1	1
2	A99Q0062	13-Apr-99	LOC(BC) 29	342 agl	200 overcast	1	1/4 in heavy snow	yes	4	0
3	A99A0036	17-Mar-99	NDB 32	1295 agl	150-200	?	? blowing snow	no	1	1
4	A99Q0005	04-Jan-99	LOC/DME 20	483 agl	300	1 1/2	1/2 in moderate snow	no	0	0
5	A98Q0043	28-Mar-98	ILS-CAT 1 06	200 agl	100	1/2 RVR 26	1/2 1200 RVR Fog	yes	0	0
6	A98W0043	14-Mar-98	ILS-CAT 1 29	200 agl	200	02-Jan	1/8 fog	yes	5	0
7	A98W0011	20-Jan-98	NDB 25	457 agl	400 agl overcast	1 1/2	3 blowing snow & mist	yes	0	0
8	A97H0011	16-Dec-97	ILS-CAT 1 15	200 agl	100 obscured	1/2 RVR 26	1/8 1200 RVR Fog	yes	0	9
9	A97C0235	07-Dec-97	NDB 34	562 agl	400 overcast	1 3/4	3 freezing drizzle	yes	0	0
10	A97C0236	09-Dec-97	NDB A	555agl	200 overcast	?	1 fog & snow showers	no	4	13
11	A97A0078	15-Apr-97	NDB A	1072 agl	100 broken	3	1 1/4 light drizzle & mist	yes	0	0
12	A97C0026	16-Feb-97	LOC(BC) 18	379agl	300 obscured	1 1/4	1/2 (1 1/2 reported)	yes	0	0
13	A96A0035	08-Mar-96	LOC/BC	298 agl	300 overcast	1	1 1/2 light freezing drz & fog	yes	0	0
14	A96O0021	08-Feb-96	NDB 09	575 agl	200 overcast	1 1/2	2 light drizzle & fog	yes	0	0
15	A95A0093	11-May-95	ILS 1	255 agl	200 obscured	1	< 5/8 in fog	yes	0	0
16	A95H0012	27-Sep-95	ILS 11	200 agl	300 overcast	1/2 RVR 26	2light rain & fog	yes	8	2
17	A94Q0215	23-Nov-94	LOC(BC) 27	420 asl	0 obscured	1	<1 in heavy snow	yes	0	0
18	A94Q0088	19-May-94	LOC(BC)/DME 31	515 agl	100 partially obscured	1 1/2	1/2 fog	no	0	0
19	A94C0014	27-Jan-94	NDB 08	604 agl	400 obscured (reported 500)	?	3 ice fog & snow	no	2	0
20	A94A0003	04-Jan-94	NDB/DME 10	507 agl	400 obscured	1 1/2	1/4 to 1/2 sn & bs	yes	2	0
21	A00H0001	27-Feb-00	NDB 06	695 agl	300 ovcst	2	3 in fog	yes	0	2
22	A00O0111	13-Jun-00	NDB 09	575 agl	400 ovcst	2	9 in fog	yes	0	0
23	A00P0244	31-Dec-00	LOC DME B 16	1851 agl	sky obscured	3	3/4 in snow	yes	4	0
24	A01W0261	15-Oct-01	NDB 20	894 AGL	500 OVCST	2 1/2	1 1/2 in snow	no	3	0

Appendix E—Glossary

agl	above ground level
AIRMET	airman's meteorological advisory
ALT	altitude encoding
AME	aircraft maintenance engineer
asl	above sea level
ATPL	airline transport pilot licence
BC	back course
CAP	*Canada Air Pilot*
CARAC	Civil Aviation Regulation Advisory Council
CARs	*Canadian Aviation Regulations*
CASO	Commercial Air Service Operations
CRM	crew resource management
CVR	cockpit voice recorder
DH	decision height
DME	distance-measuring equipment
EDT	eastern daylight time
ELT	emergency locator transmitter
ERS	emergency response services
FDR	flight data recorder
fpm	feet per minute
FSS	Flight Service Station
GO&FR	General Operating and Flight Rules
GPS	global positioning system
GPWS	ground proximity warning system
IFR	instrument flight rules
in Hg	inches of mercury
kg	kilogram
LAAS	local area augmentation system
LOC	localizer transmitter
MAP	missed-approach point
MDA	minimum descent altitude
MHz	megahertz
NDB	non-directional beacon
nm	nautical miles
NPA	notice of proposed amendment
PDM	pilot decision making
RAIM	receiver autonomous integrity monitoring
RVR	runway visual range
sm	statute mile(s)
SOPs	standard operating procedures

TC	Transport Canada
TROWAL	trough of warm air aloft
TSB	Transportation Safety Board of Canada
TSO	Technical Standard Order
UTC	Coordinated Universal Time
VOR	very high frequency omnidirectional range
V_{ref}	calculated approach speed
WAAS	wide area augmentation system
°	degree(s)
'	minute(s)
"	second(s)