AVIATION INVESTIGATION REPORT
A00H0005

RUNWAY EXCURSION

FIRST AIR
BOEING 727-200 C-GXFA
IQALUIT AIRPORT, NUNAVUT
22 SEPTEMBER 2000

Aviation Investigation Report

Runway Excursion

First Air
Boeing 727-200 C-GXFA
Iqaluit Airport, Nunavut
22 September 2000

Report Number A00H0005

Summary

The Boeing 727, C-GXFA, operating as First Air Flight 860, was on a scheduled flight from Ottawa, Ontario, to Iqaluit, Nunavut, with 7 crew members and 52 passengers on board. Iqaluit Airport was receiving its first major snow squall of the winter, and snow-clearing operations were under way. The wind was from the east at approximately 20 knots with gusts to 30 knots. The snow-clearing vehicles left the runway and remained clear while the flight was conducting an instrument approach to Runway 35. Because of strong winds, the approach was discontinued approximately five nautical miles from the airport, and a second approach to Runway 35 was carried out. After touching down near the runway centreline, the aircraft travelled off the left side of the runway, then returned to the runway surface. The aircraft then drifted to the left and came to rest 7000 feet from the threshold of Runway 35. The nose wheels and the left main wheels were off the runway in the mud west of the runway. An emergency evacuation was ordered, and all passengers and crew exited the aircraft without injury. The aircraft received only minor damage.

Ce rapport est également disponible en français.

Table of Contents

1.0 Factual Information

1.1 History of the Flight

First Air Flight 860 (FAB 860) was a scheduled flight from Ottawa/MacDonald-Cartier International Airport, Ontario, to Iqaluit, Nunavut, with a flight plan time of 2 hours 44 minutes. The flight, a combi configuration (passengers and freight) with 7 crew members and 52 passengers on board, departed Ottawa at 0853 eastern daylight time, 0953 central daylight time.[1] Freight was loaded in the forward part of the aircraft; passengers were seated in rear of the cabin, behind a bulkhead. Among the passengers were several nonrevenue Boeing 727 cockpit and cabin crew personnel from First Air.

En route, the flight crew received reports on the weather in Iqaluit and the weather and the reported runway condition for their alternate airport, Sondre Stromfjord, Greenland, from the company dispatch office in Ottawa. The planned approach was an instrument landing system (ILS) approach to Runway 35. The autopilot in the occurrence aircraft had a long history of unstable flight characteristics when used in turbulence or rough air, so the captain hand-flew the aircraft during the approach. Because of strong crosswinds from the east and wind shear, the captain had difficulty intercepting the localizer centreline and discontinued the approach about five nautical miles (nm) from the airport. The crew reviewed their alternate airport conditions and the computer flight plan diversion fuel and confirmed that Sondre Stromfjord was suitable for diversion. The crew indicated that the fuel on board allowed for one more approach.

The captain turned the aircraft toward the southwest and climbed to 5000 feet above sea level (asl) to avoid flying north of the airport because of reported severe turbulence in that area. He then flew the aircraft in a left pattern back toward the southeast. The captain continued to hand-fly the aircraft for the second ILS approach because of considerable mechanical turbulence. The aircraft intercepted the localizer from the southwest and was already established on the glidepath by the time the localizer was intercepted. At an altitude of about 600 feet above the runway, the on-board navigation system indicated a wind of 030 degrees true (°T) at 25 knots.

---

[1] All times are central daylight time (Coordinated Universal Time [UTC] minus five hours). At the time of the occurrence, Nunavut was in the central time zone. As of 01 April 2001, Nunavut is in the eastern time zone.

Shortly after touching down near the centreline of the runway, the aircraft began to drift to the left. Both main landing gears slid completely off the runway. The nose wheel to the right of the main gear remained on the runway. Because of the drift angle, the cockpit area was over the runway surface, and the cockpit crew were not aware that the aircraft had left the runway surface. The aircraft returned completely to the runway surface but then began to drift left again as reverse thrust was applied. At this point, the crew had concerns that limited runway remained, and the decision was made to use the thrust reversers even though it was known that the aircraft could drift to the left again. The left wheel exited the runway, but the right main gear and the nose gear remained on the runway until just before the aircraft slowed to a stop. At the last moment, with the left main gear in the unprepared area to the left of the runway, the aircraft pivoted nose-left and came to rest 7000 feet from the threshold of Runway 35. At 1200, the captain called for the emergency evacuation drill. The first officer made the evacuation announcement, but, because of the manner in which he set up the passenger address (PA) system, the announcement was not heard in the cabin. Subsequently, all passengers and crew evacuated the aircraft without injury.

1.2 Injuries to Persons

	Crew	Passengers	Others	Total
Fatal	-	-	-	-
Serious	-	-	-	-
Minor/None	7	52	-	59
Total	7	52	-	59

1.3 Damage to Aircraft

The aircraft sustained minor damage. Both left main tires were worn through from skidding and deflated. The left nose-wheel tire was also deflated because of the side loads encountered as the aircraft came to a stop. There was minor damage to the aircraft skin near the wing root area, the left inboard flap, and the left inboard spoiler panel.

1.4 Other Damage

Some runway lights on the left side of the runway were broken when they were struck by the aircraft wheels during the left-side excursion.

1.5 Personnel Information

	Captain	First Officer
Age	40	38
Pilot Licence	ATPL	ATPL
Medical Expiry Date	01 November 2000	01 October 2001
Total Flying Hours	7977	3315
Hours on Type	3518	455
Hours Last 90 Days	102	165
Hours on Type Last 90 Days	102	165
Hours on Duty Prior to Occurrence	4.5	4.5
Hours off Duty Prior to Work Period	16	84

1.5.1 General

The Boeing 727 cockpit crew comprised the captain, the first officer, the second officer, and the flight engineer (F/E) instructor, who was training the second officer. The cabin crew comprised a purser, who was in charge of the cabin, and two flight attendants.

1.5.2 Captain

The captain had 13 years' experience with First Air and had 7 years' experience on the Boeing 727 as a captain, first officer, and second officer. He had been qualified as a Boeing 727 captain since January 1998. He had also previously been qualified on the de Havilland DHC-6 and the Hawker Siddeley HS-748 aircraft operated by the company and had flown into Iqaluit on many occasions.

The captain had recently undergone training on slippery runway conditions and crosswind landings. This training occurred during his last recurrent simulator sessions. No problems were noted in the training record. The captain's most recent crew resource management training was on 17 February 2000. He had completed the Transport Canada (TC) Pilot Decision Making program training on 15 January 1999.

1.5.3 First Officer

The first officer joined the airline in 1995 and completed flight training as a Boeing 727 second officer in February 1995. In 1998, he completed training on the Hawker Siddeley HS-748. He received training as a Boeing 727 first officer in November and December 1999 and completed his line check on 20 January 2000. The first officer completed crew resource management training in December 1999 and had flown into Iqaluit on many occasions.

1.5.4 Second Officer

The second officer had recently been hired by the airline. He was undergoing line-indoctrination training on the occurrence flight and was being monitored by the F/E instructor. The second officer completed crew resource management training in August 2000.

1.5.5 Flight Engineer Instructor

The F/E instructor was the lead F/E for the company. He had been a Boeing 727 F/E for more than 14 years. The F/E held an aircraft maintenance engineer licence and is a simulator instructor.

1.5.6 Cabin Crew

The purser for the flight had been with the company for more than 11 years. Her last training for unplanned passenger evacuation was on 18 October 1999, valid to 01 November 2000. One of the flight attendants had 10 years with the company as a flight attendant; his last training for an unplanned passenger evacuation was on 28 October 1999, valid until 01 November 2000. The other flight attendant had 3 years' experience with the company as a flight attendant; her training for an unplanned passenger evacuation was on 25 October 1999, valid until 01 November 2000.

1.6 Aircraft Information

Manufacturer	Boeing Commercial Aircraft Co.
Type and Model	727-233
Year of Manufacture	1975
Serial Number	20938
Certificate of Airworthiness	31 May 1991
Total Airframe Time	60 663 hours
Engine Type (number of)	Pratt & Whitney JT8D-15 (3)
Maximum Allowable Take-off Weight	197 000 pounds

1.6.1 General

Records indicate that the aircraft was being maintained in accordance with existing standards and regulations. There were no aircraft unserviceabilities with the landing gear or flight control systems.

1.6.2 Weight and Balance

The aircraft's maximum allowable take-off weight is 197 000 pounds, and the maximum allowable landing weight for a flap-30 landing is 164 000 pounds. The calculated take-off weight from Ottawa was 190 000 pounds, with a fuel weight of 49 000 pounds. The landing weight was 161 000 pounds. The centre of gravity was within the normal limits at all times.

1.6.3 Auto Speedbrakes (Ground Spoilers)

The Boeing 727-200 auto speedbrakes (ground spoilers), if armed before landing, are designed to automatically deploy on landing. The on-ground logic to deploy the auto speedbrakes consists of a weight-on-wheels switch on the left main landing gear and spin-up of either main wheel. The auto speedbrakes will retract if the thrust levers are moved forward.

1.6.4 Passenger Address System

Flight crew announcements are directed to the cabin through the PA system. Announcements can be made from the cockpit using a hand microphone on the control stand between the captain and the first officer or, in some aircraft, using a hand microphone or a boom microphone through the flight crew's audio selector panel. The First Air Boeing 727 fleet has three types of audio selector panels. Two of the panels have a rotary transmitter selector switch that allows the flight crew to transmit on VHF (very high frequency)-1, VHF-2, HF (high frequency), Int (interphone), or PA. The third type of audio selector panel, which was installed on the occurrence aircraft, does not have a rotary switch, but uses pushbuttons to select transmitters. The pushbutton for PA is for use only with the oxygen mask microphone. A PA announcement will not be heard in the passenger cabin if the flight crew member uses the boom microphone or the hand microphone through the audio selector panel. Therefore, unless an oxygen mask is used, a PA announcement on the occurrence aircraft can only be made using the hand microphone on the control stand.

The simulator used for the crew training was not equipped with a centre-console PA microphone, and simulated announcements in training were accomplished with the copilot interphone panel.

1.7 Meteorological Information

1.7.1 Actual Weather

At the time of the occurrence, Iqaluit was experiencing strong winds from a low-pressure system and its first major snow squall of the winter.

At 1100, the flight service station (FSS) issued the following weather observation: wind 070°T at 21 knots gusting to 31 knots; visibility 1 statute mile (sm) in light snow showers; runway visual range (RVR) 6000 feet for Runway 35; vertical visibility 800 feet; temperature 2°C; altimeter setting 29.14 inches of mercury; and an 8/8 ceiling obscuration.

At 1138, the FSS issued the following special weather observation: wind 050°T at 21 knots gusting to 30 knots; visibility 3/4 sm in snow showers; RVR 3000 feet for Runway 35; vertical visibility 200 feet; and an 8/8 ceiling obscuration.

At 1200, the FSS issued the following weather observation: wind 050°T at 20 knots gusting to 31 knots; visibility 1½ sm in light snow showers; vertical visibility 500 feet; temperature 1°C; altimeter setting 29.14 inches of mercury; an 8/8 ceiling obscuration; and wet snow.

The wind information was recorded every two minutes by the automated weather observation system (AWOS). At 1158, about two minutes before the occurrence, the AWOS wind value was 052°T at 18 knots, with gusts to 29 knots. The wind direction resulted in a crosswind component from the right near the maximum of 29 knots and a maximum downwind component of less than 3 knots for an aircraft landing on Runway 35.

The flight crew of FAB 860 had the 1100 weather report, and it was recorded on their landing data card for the approach into Iqaluit. The crew did not receive the 1138 weather from either the FSS or the airline dispatch office.

1.7.2 Forecasted Weather

The terminal forecast (TAF) for Iqaluit issued on 22 September 2000 at 1047, valid for the time period of FAB 860's arrival (1000 to 1300), was as follows: wind 070°T at 20 knots; visibility 3 sm in light snow and mist; scattered clouds at 200 feet above ground level (agl); overcast cloud at 1000 feet agl; temporarily, wind 130°T at 30 knots gusting to 40 knots; visibility ½ sm in snow; and overcast cloud at 100 feet agl.

1.7.3 Pilot Weather Reports (PIREPs)

The crew of a First Air Hawker Siddeley HS-748 aircraft, which was heading north out of Iqaluit, reported severe turbulence on departure. The occurrence flight was told of this weather information by the crew of the HS-748, about 25 minutes before the occurrence landing.

1.8 Aids to Navigation

There were no reported problems with the VOR (very high frequency omnidirectional radio range), DME (distance-measuring equipment), or ILS systems at Iqaluit. The ILS was flight checked after the occurrence and found to be operating normally.

1.9 Communications

1.9.1 Radio Communication Interference

Nav Canada provides flight information and ground vehicle control service at Iqaluit Airport through an on-site FSS. Several radio frequencies, whose related antennae are across the runway in an antenna farm, had experienced significant interference. The FSS sought to eliminate or reduce the radio noise by using backup radios in the FSS; this did not rectify the situation. The peripheral radio frequencies used by the Montréal Area Control Centre to communicate with aircraft in the Iqaluit vicinity were similarly affected by interference. It was reported that the interference was caused by the adverse weather, and there was nothing the technician could do to resolve the problem.

During replay of the recorded radio frequencies, it was determined that all frequencies were subject to the interference, except for 122.6 MHz, the ground control frequency. Because the antenna for this frequency is near the terminal building, the FSS and is less exposed to the weather than are the antennae for the other frequencies, which are in the open.

1.9.2 Sequence of Radio Communications

1118 The FSS requested all vehicles to vacate the runway because of uncertainty about the position of FAB 860, given that the revised estimated time of arrival for the aircraft was 1125.

1120 The field maintenance foreman asked whether a notice to airmen (NOTAM) would be sent regarding the inability to continue snow removal on the runway. The FSS indicated that this was an airport management responsibility; neither the FSS nor airport management took further action on issuing a NOTAM. All vehicles are clear of the runway and proceed to remove snow from the ramp area.

1121 The airport manager requested the latest runway surface condition (RSC) report from the field maintenance foreman. The field maintenance foreman reported that at 1015 the runway conditions were 195 feet (of the runway width) bare and wet and that the Canadian runway friction index (CRFI) was 0.60. (The reading of 0.60 was taken at 0907.) The airport manager acknowledged this report.

1122 FAB 860 contacted Iqaluit FSS; the aircraft was in descent through 21 500 feet and 75 nm back from the runway.[2]

1124 FAB 860 requested an RSC report. The FSS advised FAB 860 that the radio interference had cleared up but, in the event of renewed interference and lost communications, he provided airport information to the crew, including the fact that all vehicles were off the runway and would remain off until the aircraft had landed. Information regarding the latest RSC report, wind direction and speed, altimeter setting, and a recent PIREP concerning severe to extreme turbulence north of Iqaluit was also relayed.

1135 FAB 860 reported 15 nm from Iqaluit. The FSS informed the crew that the wind was 090° magnetic (M) at 25 knots gusting to 30 knots with peak gusts to 35 knots. The RVR was reported as 4000 feet and the runway lights at strength five.

1137 A special weather report, just taken by the FSS, was reported to the crew as precipitation ceiling 200 feet overcast, visibility 3/4 sm, and an RVR 3000 feet (but read back by the crew as 2000 feet). There was no mention that light snow showers reduced visibility.

1140 FAB 860 reported to the FSS that they were carrying out a missed approach and that their intention was to hold on the localizer to the south of Iqaluit at 5000 feet. When asked for their further intentions, FAB 860 reported that they planned to hold just long enough to receive the updated weather and that it was wind shear on the approach, not turbulence, that contributed to the decision to carry out the missed approach.

1147 The FSS requested a clearance from the Montréal Area Control Centre and subsequently issued a clearance to FAB 860 to hold on the localizer at 5000 feet. Shortly thereafter, FAB

---

[2] FAB 860 was instructed to contact the FSS at 75 nm from Iqaluit because of radio interference problems on Montréal's frequency of 132.55 MHz.

860 requested another approach clearance, which FSS requested and received from the Montréal Area Control Centre and transmitted to FAB 860.

1155 FAB 860 reported to the FSS that they were at 10 nm on final for Runway 35. The FSS stated that the wind was 090°M at 20 knots gusting to 25 knots with some gusts to 30 knots. The RVR was reported at 6000 feet plus and the runway lights were at strength five.

1157 FAB 860 reported turning final and again received wind information, 090°M at 20 knots gusting 25 knots. The crew requested that the runway lights be set at strength five and were told that the lights were at that setting.

1200 FAB 860 advised FSS that they were evacuating the aircraft and requested emergency equipment.

1.10 Aerodrome Information

1.10.1 General

Iqaluit Airport is a certified airport operated by the government of Nunavut. It is served by a single, asphalt-surfaced runway, 9000 feet long by 200 feet wide, designated 17/35. The heading of Runway 35 is 354°M or 316°T. The thresholds for both ends of the runway are displaced 200 feet, giving a landing distance available of 8600 feet. Runway 35 approach lighting is nonstandard 700-foot centre row, Category 1, combined high- and low-intensity lighting. The runway identification lights are unidirectional flashing strobe lights, and the runway has threshold and runway end lights and high-intensity runway edge lights, variable over five settings.[3] Distance-to-go markers are located every 1000 feet on both sides of the runway. The surface adjacent to the runway is gravel, dirt, and sand, which at the time of the occurrence was wet and muddy.

Runway 35 is served by an ILS approach with a glide path of 2.5°. The decision height for the approach is 280 feet asl or 200 feet above the touchdown elevation of 80 feet asl.

The airport manager is responsible for ensuring that airport field maintenance services are provided. A contracted private firm, Narwhal Arctic Services, provides these services. The supervisor of airport field maintenance, an employee of Narwhal Arctic Services, is responsible for carrying out required snow and ice control as defined in the *Iqaluit Airport Snow Removal and Ice Control Action Plan.*

---

[3] The different types of lighting are described in *Canada Flight Supplement.*

1.10.2 Iqaluit Airport Snow/Ice Removal Plan

The *Iqaluit Airport Snow Removal and Ice Control Action Plan*, dated 28 August 2000, contains the policies, priorities, guidelines, and responsibilities pertaining to snow removal and ice control at Iqaluit Airport. This publication defines the centre 100 feet of the runway as first priority and specifies that the maximum allowable precipitation accumulation is as follows:

Loose snow	No more than 4 inches
Compacted snow	No more than 2 inches
Wet snow	No more than 1 inch
Slush or standing water	No more than ½ inch

Part 7 of the *Iqaluit Airport Snow Removal and Ice Control Action Plan* specifies that only the airport manager or his/her designated representative has the authority to close the runway, taxiways, or any other movement areas.

Part 8 details RSC reporting. Observable contaminants and conditions that must be reported as part of an RSC report include, among other items, slush, wet snow, and bare and wet sections. Surfaces are to be inspected as follows:

- at the commencement of each work shift
- at least once every eight-hour shift
- at the end of every shift
- every time the runway has been cleared of contaminants
- whenever the cleared width falls below 100 feet
- after the application of sand or urea
- each time the runway is swept after the application of sand or urea
- every time there is a significant change in the runway surface conditions
- in response to a reasonable request by an air carrier
- following any accident or incident involving aircraft or vehicles on the runway

Approximately seven minutes is required to complete a full RSC report on Runway 17/35 at Iqaluit.

1.10.3 Airport Vehicle Operations

An agreement between the FSS and airport management establishes the responsibilities and the procedures for FSS control of vehicular traffic on the manoeuvring areas of Iqaluit Airport. The agreement also establishes the procedures for all special operating conditions. The FSS is to coordinate all vehicle movements on the manoeuvring areas, ensure the runway is cleared of vehicles before any aircraft's departure or landing, and advise the airport management of weather that may adversely affect the safe operation of aircraft on the manoeuvring areas.

The airport management is responsible for notifying the FSS when the airport is unserviceable for aircraft operations and for ensuring that immediate action is taken to correct unsafe conditions on the manoeuvring areas. Airport management procedures include coordinating planned changes that will affect manoeuvring areas where airport vehicle control service will be in force. Airport management will also coordinate NOTAMs about the availability of manoeuvring areas to aircraft and about unsafe conditions that cannot be immediately corrected.

1.10.4 TC Aerodrome Safety Circular on Runway Condition Reporting

In response to concerns expressed by some aerodrome operators, TC reviewed the existing Aircraft Movement Surface Condition Report (AMSCR) program. On 15 September 2000, seven days before the occurrence, TC issued *Aerodrome Safety Circular* (ASC) 2000-002. The circular was intended to provide "one collective reference" on the topic of AMSCR: "The purpose of this circular is to provide a complete and standardized description of the essential elements and procedures currently in use for winter surface condition reporting for aircraft movement areas." The Iqaluit airport manager did not see ASC 2000-002 until after this occurrence, although it was released on 15 September 2000.

1.10.5 Runway Conditions

On 22 September 2000, Narwhal Arctic Services maintenance personnel inspected the runway surface three times before the occurrence and once immediately after. The first, at 0657, reported in AMSCR No. 608-00 that the runway was 100% covered in 1/4 inch of slush / wet snow, the temperature was -0.5°C, and the CRFI was 0.42. The foreman indicated on the report that snow removal operations were to commence at 0710.

The second AMSCR, No. 609-00, was performed at 0907 after snow removal operations had cleared most of the runway. The report indicated that the runway was cleared to a width of 175 feet and that this portion was bare and wet. The remaining 25 feet of the runway remained 100% covered with 1/4 inch of slush / wet snow, with windrows 4 inches high. The CRFI was recorded as 0.60, and the temperature was 2°C.

The third AMSCR, No. 610-00, was completed at 1035 and indicated that 195 feet of the runway width was 100% bare and wet. The remaining 5 feet on the side was a 4-inch windrow of slush. The temperature was recorded as 2.5°C. No CRFI was taken. All three reports were appropriately communicated to the FSS for use as required.

At 1200, the Narwhal Arctic Services maintenance foreman and the site supervisor began a post-incident RSC report that was completed at 1207. This AMSCR, No. 611-00, indicated that the runway was 100% covered by 1/4 inch of slush / wet snow. The temperature was 1°C, and the CRFI was 0.34.

After the occurrence, it was noted by passengers and crew of the occurrence aircraft that the runway was very slippery to walk on and covered in slush. When observed from the cockpit on approach and from the FSS building, the runway appeared to be wet, not snow covered.

1.10.6 Information Available to Flight Crews Regarding Runway Condition

TC's *Aeronautical Information Publication*, Airmanship (AIR), article 1.6.4, describes RSC and CRFI reporting as follows:

> RSC/CRFI NOTAMs are issued to alert pilots of natural surface contaminants, such as snow, ice or slush, that could affect aircraft braking performance.
>
> RSC/CRFI NOTAMs are distributed on AFTN/ADIS[4] upon any of the following conditions:

[4] AFTN/ADIS is aeronautical fixed telecommunication network/automated data interchange system

(a) slush or wet snow on the runway;

(b) loose snow on the runway exceeding 1/4 in. in depth;

(c) the runway is not cleared to the full width. When the runway is partially cleared the report will also include a description of the uncleared portion of the runway (depth of snow, windrows, snowbanks, etc.);

(d) packed snow or ice (frost) on the runway; or

(e) the CRFI reading is 0.40 or less.

When a contaminant is such that it meets the conditions for teletype distribution and clearing is not under way or not expected to commence within the next 30 minutes, a notation such as “CLEARING EXPECTED TO COMMENCE (TIME IN UTC)” will be added to the RSC report.

TC publishes the “Canadian Runway Friction Index” chart (Appendix A) in numerous publications. The chart provides headwind and crosswind components of a reported wind with respect to the runway. The vertical lines of the crosswind component also indicate the minimum recommended CRFI for the reported crosswind component. Landing when the reported CRFI is below this minimum could result in uncontrollable drifting or yawing. TC also publishes a “CRFI Equivalent” chart (Appendix A). This chart approximates the CRFI and provides guidance on runway surface conditions when no CRFI is reported. *Aeronautical Information Publication,* section 1.1.4, states: “Experience has shown that results obtained from the various types of decelerometers on water and slush are not accurate, and the CRFI will not be available when these conditions exist.”

1.11 Flight Data Recorders

The aircraft was equipped with a Lockheed Corporation digital flight data recorder (DFDR), serial number 276, which was analyzed by the TSB Engineering Laboratory in Ottawa, Ontario. (See Appendix B.) The DFDR recorded the occurrence landing, and all parameters worked correctly except the No. 2 engine pressure ratio. A comparison with parameters from engine No. 1 and engine No. 3 indicated that there were no engine anomalies associated with the occurrence.

The aircraft touched down at approximately 1200. The recorded airspeed at touchdown was 151 knots indicated airspeed (KIAS), and the aircraft heading was approximately on the runway heading. The vertical acceleration at landing was 1.4*g*, followed by two seconds with less than

1.0*g*. About four seconds after touchdown, the aircraft heading began to increase and reached an angle relative to the runway heading of 30° right. The ground track shows that the aircraft travelled off the left side of the runway during this time.

The DFDR showed that the ground spoilers (speedbrakes) extended about one second after touchdown and retracted about eight seconds later when the thrust levers were advanced for a few seconds. All this happened at the first point of maximum drift angle as the aircraft was returning to the runway surface. Shortly after this, the thrust levers were returned to idle and reverse thrust was selected. The first indication of reverse thrust actuation was about 11 seconds after the initial touchdown. The spoilers extended again at this point and remained extended until after the aircraft came to a stop. Initial longitudinal deceleration was relatively low (peak about -0.25 average), but at about 70 KIAS, as the left main wheel was off the runway surface, the longitudinal acceleration went to a maximum value of -0.8*g*. (Normal landing braking deceleration is -0.3*g* to -0.4*g*.)

1.12 Crosswind Landing Information

1.12.1 Landing and Approach Speed

The reference speed (V_{REF}) for a landing weight of 161 000 pounds is 138 KIAS. In accordance with First Air's *Boeing 727 Operations Manual*, for a flap-30 landing, the speed set on the airspeed indicator, known as bug speed, would be 142 KIAS. The Boeing-recommended correction applied to the approach speed is one-half of the steady wind plus all of the gust value up to a maximum of 20 knots. Because of the wind, the crew used 160 KIAS as the planned approach speed.

1.12.2 Landing Distance Required

The flight crew calculated that the required landing distance in Iqaluit was less than 8800 feet. Following the occurrence, investigation staff, using the Boeing 727-200 "Landing Field Length—Flaps 28" table in the *Boeing 727 Performance Manual*, calculated that, for the occurrence flight, the required factored[5] runway distance for a wet runway is 6200 feet. This distance includes the 60% dispatch factor.

There is no certification requirement to provide charts for contaminated runways; however, First Air provides slippery runway guidance for the Boeing 727 flight crews in the "Slippery Runway Landing" table in the *Boeing 727 Performance Manual*. Two columns describe the runway conditions: the first column uses a CRFI value; the second has RSC descriptions to be used for entry. According to the table, for the measured CRFI of 0.34 (taken just after the occurrence), the "flaps 30" landing distance is about 5100 feet. For a "snow-covered" runway,[6] the table indicates that the "flaps 30" landing distance is about 5800 feet. The table does not have a "slush-covered" runway selection. The available landing distance for Runway 35 at Iqaluit is 8600 feet.

1.12.3 Crosswind Limitations

The crosswind limitations, as stated in First Air's *Boeing 727 Operations Manual*, are as follows:

---

5 Factored landing distance is the landing distance required, which includes the flare and the stopping distance, with a factor of 1.667, in accordance with certification requirements.

6 The table describes a snow-covered runway as having a CRFI of .25 to .3.

Maximum demonstrated crosswind is 29 knots (dry runway). It is recommended that an alternate runway should be considered if the crosswind component exceeds:

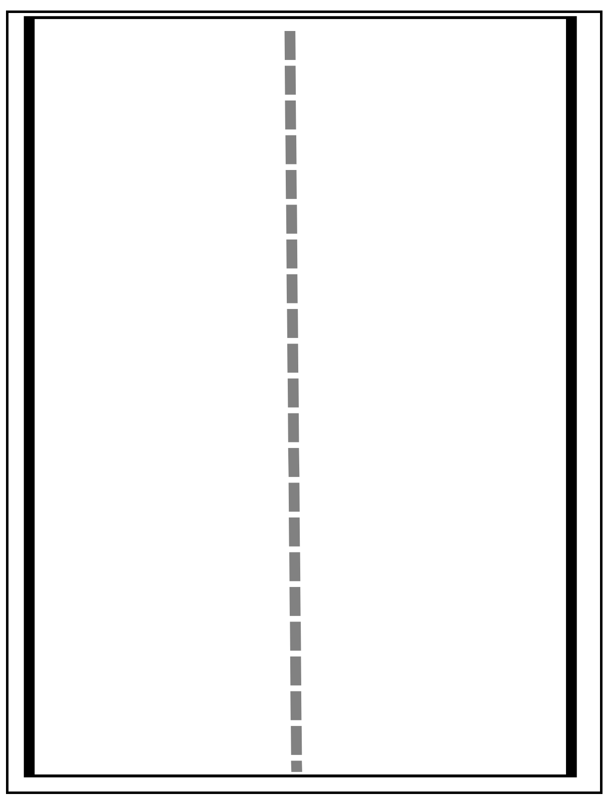
Dry Runway	29 knots
Wet/Slippery Runway	20 knots
Icy Runway	10 knots

After receiving numerous customer inquiries regarding landing in high crosswinds, Boeing undertook an extensive program to improve its crosswind landing guidelines for all current production models of aircraft. In the July–September 1996 issue of the Boeing safety newsletter *Airliner*, an update of the crosswind guidelines recommends a maximum crosswind of 4 to 12 knots for a Boeing 727 landing on standing water or slush. In a subsequent study, Boeing recommended 15 knots in the same conditions where asymmetric reverse thrust is applied. Because the Boeing 727 was out of production, the guidelines for this aircraft were based on analytical models and simulator trials; performance has not been demonstrated in an aircraft.

1.12.4 Crosswind Landing Handling

First Air's *Boeing 727 Operations Manual*, Supplementary Procedures section, Adverse Weather, describes landing in a crosswind as follows: "In crosswind conditions, the crosswind crab angle should be maintained to touch down on very slippery runways. Allowing the airplane to touch down without removing the crab angle will reduce drift toward the downwind side of the runway on wet or icy runways."

First Air's *Boeing 727 Operations Manual*, Normal Operating Procedures section, Crosswind Landing, states that "[d]uring strong crosswind conditions rudder authority is inadequate to maintain runway centreline and crab will be required." It also states that "the crosswind component beyond which rudder authority is inadequate" for an aircraft weight of 160 000 pounds is 23 knots. Landing with crosswind components higher than 23 knots is permissible but requires crabbing into wind. Crews have indicated that the aircraft is landed with little difficulty on wet runways with crosswinds as high as the demonstrated crosswind value, but for icy runways, the acceptable crosswind value is much lower.



First Air's *Boeing 727 Operations Manual*, Supplementary Procedures section, Adverse Weather, discusses the use of reverse thrust in a crosswind. The reverse thrust side force component and a crosswind can cause the airplane to drift to the downwind side of the runway if the airplane is allowed to weathervane into the wind. As the airplane starts to weathervane into the wind, the reverse thrust side force component adds to the crosswind component and drifts the airplane to the downwind side of the runway. Main-gear tire cornering forces available to counteract this drift will be reduced when the antiskid system is operating at maximum braking effectiveness for existing conditions.

1.13 Emergency Evacuation

1.13.1 The Evacuation

When the aircraft came to a stop, the emergency evacuation checklist was commenced in accordance with company procedures. The first officer made the PA announcement using the first officer's audio selector panel. There appeared to be some second thoughts on the part of the captain about the immediate necessity for actually evacuating the passengers, but it was thought that the passengers had already received the command to evacuate and there was no further hesitation in completing the checklist.

The announcement made by the first officer was not heard in the cabin. A cabin crew member attempted to contact the cockpit, using the interphone system for more information or direction, but there was no reply to the call. The call chime was recorded on the cockpit voice recorder but was not heard by the pilots.

After coordinating with the cabin crew, one of the company nonrevenue passengers moved to the freight area separating the cockpit and the cabin and asked the cockpit crew whether the passengers were to evacuate. Upon receiving a positive reply, he informed the cabin crew, who then gave the order to evacuate. At the same time, a nonoperating crew member, also travelling as a passenger, announced for the passengers to deplane. The passengers quickly evacuated using the two rear side exit slides, the two overwing exits, and the rear stairs. Other airline employees who were travelling as passengers also assisted in the passenger evacuation.

The door slide on the left front door nearest the cockpit was not deployed. After leaving the cockpit, the crew looked back from the open door. They did not see any immediate safety threat, so they decided not to deploy the slide. The cockpit crew passed through the cargo area and left the aircraft through the rear stairs. No one was injured during the evacuation.

Many of the passengers were dressed in light clothing and were not wearing their jackets and coats when they evacuated the aircraft. After it was assessed that it was safe to reboard the aircraft, some cabin crew members entered the cabin through the rear stairs and obtained blankets for some passengers. Some passengers began walking down the runway toward the terminal, which was about a mile away. The cabin crew marshalled the passengers together to complete a head count. The first officer boarded the aircraft to contact the FSS operator, via the aircraft radio, to request transportation for the passengers and crew. By this time, the airport management had already arranged for vehicles to transport the passengers and the crew back to the terminal building.

1.13.2 Emergency Evacuation Checklist

First Air's *Boeing 727 Operations Manual* states that the emergency evacuation checklist is to be initiated "when a condition exists that potentially endangers life or physical well being of passengers and crew." Flight crews are instructed not to call for the checklist until the parking brake is set. The checklist has duties for the captain (C), the first officer (F/O), and the second officer or the F/E that are to be carried out simultaneously. While the first officer is notifying the cabin attendants of the evacuation, the flaps are selected to full down. In the meantime, the captain stows the speedbrakes, shuts down the engines, and, if necessary, discharges the fire bottles. The PA announcement for an emergency evacuation is "Cabin Attendants . . . Evacuate . . . Evacuate." If an emergency evacuation is not required, the passengers are deplaned through the rear airstair.

Tower/Ground Crew/Cabin Attendants	NOTIFY	F/O
Parking Brakes	SET	C
Speedbrake Lever	FULL FORWARD	C
Flap Lever	FULL DOWN	F/O
Start Levers	CUTOFF	C
Engine Fire Switches	PULL	C
Fire Bottles (if required)	DISCHARGE	C
Essential Power Source Selector	STANDBY	F/E
Ground Venturi Switch	GROUND VENTURI	F/E
Outflow Valves (if required)	OPEN	F/E
APU Fire Switch	PULL	F/E
APU Fire Bottle (if required)	DISCHARGE	F/E
Passenger Evacuation	ASSIST	ALL

Boeing's passenger evacuation checklist in its 727 *Flight Crew Operating Manual* was reviewed during the investigation. The items on this checklist are similar to the First Air checklist; however, the order of the items is different. Boeing's checklist initiates the evacuation after the engines are shut down and the speedbrakes are stowed. Evacuation checklists from other aircraft and airlines in Canada were also reviewed; all of the checklists called for the PA announcement to be made after the aircraft is safely configured for evacuation.

2.0 Analysis

2.1 Approach and Landing

At the time of the occurrence, the flight crew and airport personnel, including the FSS operator, were all hampered, to some extent, in carrying out their duties. Because the autopilot was not useable in the turbulent conditions, the captain was concentrating on hand-flying the aircraft, which affected his other flight management duties. The airport personnel were hampered by the unreliable radios at Iqaluit because of the snow accumulation on the antennae. However, the autopilot and radio problems did not contribute directly to the occurrence.

The aircraft was landed on a slippery runway in a crosswind that equalled or exceeded the demonstrated crosswind value of 29 knots on a dry runway. When considering the runway conditions, the crosswind was well above the recommended values stated in First Air's *Boeing 727 Operations Manual* and TC's *Aeronautical Information Publication*. These values are not limits, and regulations do not prohibit landing in stronger crosswind. Additionally, the captain did not use all the possible methods to improve the chances of a successful landing. For example, the aircraft heading on landing was approximately that of the runway instead of a crab into wind, in part because the captain and the other crew members were not aware of the actual runway conditions. Also, because of the strong and gusty wind, a speed increment had to be added to the basic approach speed. This extra speed further reduced the tire cornering force. The use of reverse while the aircraft was weathercocked into wind provided further forces to pull the aircraft off the runway during the second excursion. The physical and environmental reasons for the runway excursion are clear. The analysis will focus on why the landing was made in the adverse weather and runway conditions.

2.2 Runway Conditions

The latest RSC report that had been provided to the flight crew indicated that the runway was bare and wet. Once they saw the runway, the visual cues led them to believe that the runway was in fact bare and wet. They therefore had no reason to doubt the RSC report.

The snow-clearing vehicles had been working all morning keeping the runway clear of slush. A CRFI of 0.60 was taken at 0907. The runway was bare and wet until 1120, when the vehicles left the runway. The vehicle operators were told that the aircraft was due in at 1125. After the vehicles exited the runway, there was some discussion about issuing a NOTAM that the snow-clearing operations were interrupted, but none was issued. At 1121, the airport manager inquired about the runway condition, was advised of the RSC, and took no further action. The flight crew of FAB 860 were told that the vehicles were off the runway.

At 1135, while the vehicles were occupied with clearing the ramp, the weather worsened. The aircraft commenced a missed approach at 1140 and would take approximately 15 to 20 minutes to return for landing. During that time, the runway was accumulating snow and slush.

In accordance with the *Iqaluit Airport Snow Removal and Ice Control Action Plan*, the runway surface is to be inspected every time there is a significant change in the runway condition. The agreement between Iqaluit FSS and airport management requires the FSS to advise the airport operator of weather that may adversely affect the safe operation of aircraft on the manoeuvring areas.
Because the first approach had to be discontinued, there was some time to complete a runway condition reading. Nearly 40 minutes passed from when the possible need for an updated RSC report was recognized until

the aircraft touched down. An RSC vehicle is on a runway for about 7 minutes to conduct an RSC measurement. As in many operational situations, timely communication between all those involved in providing services to the flight probably would have resulted in the flight crew being more aware of their landing conditions.

The current procedures have administrative defences to provide runway surface information. Nevertheless, the occurrence showed that individual assertiveness would have been required to provide the crew with the information they needed to make a valid decision on whether to attempt the landing or to divert. FSS and airport staff did not ensure that the RSC reports were updated and passed to aircrew in changing weather conditions.

2.3 Passenger Evacuation

The evacuation enabled the passengers and the crew to exit the aircraft reasonably quickly. The passengers could have remained on the aircraft because there was no immediate indication of fire or aircraft structural damage. However, the decision to evacuate was reasonable given that the aircraft had gone off the runway surface, travelled through gravel, and come to rest canted at an unusual angle.

When the first officer was instructed to commence the emergency evacuation, his first duty was to make the "evacuate, evacuate" PA announcement. He selected the "PA OXYGEN" pushbutton on his audio selector panel and made the announcement, but nothing was heard in the passenger cabin. The type of audio selector panel installed in this aircraft will only permit PA announcements to be heard when using the oxygen mask. The flight crew were not aware that the PA announcement was not heard. The evacuation order could only have been heard in the cabin if the centre console microphone had been used. Use of this microphone would have reduced the delay and uncertainty in the evacuation. As it turns out, the aircraft was evacuated safely, with no adverse consequences. The copilot used the aircraft PA system in the same way the systems were used in the simulator for his training, but the systems were different.

The First Air emergency evacuation checklist has the passenger evacuation announcement as the first action item, followed by the aircraft configuration items, such as shutting down engines and setting flap position. This order creates the possibility that the evacuation will commence before the aircraft is configured safely for the evacuation. The safety configuration items can normally be completed quickly and would not unduly delay the announcement. In this occurrence, the captain had second thoughts about evacuating the passengers immediately, but because he believed that the announcement had already been made by the first officer, any further decision making was effectively removed from the captain.

The presence of First Air crew members as passengers assisted in the passenger evacuation. One of these passenger crew members was able to quickly contact the cockpit crew to determine if an evacuation had been ordered, facilitating the evacuation. The presence of extra trained personnel during the evacuation also enhanced passenger welfare.

After the evacuation, the lightly dressed passengers were exposed to cold, windy weather. The crew members and the nonoperating crew members travelling as passengers assisted the passengers by obtaining blankets from the aircraft, but even the crew members were not dressed warmly. At the time of the occurrence, there did not appear to be a plan to ensure that passengers were protected from the cold environment after evacuation. For this occurrence, the passengers were moved to the terminal fairly quickly because the airport management had sent a variety of vehicles.

3.0 Conclusions

3.1 Findings as to Causes and Contributing Factors

1. The runway surface condition (RSC) report, which was provided to the crew, did not accurately describe the runway condition at the time of the landing. Consequently, the aircraft was landed in wind and runway conditions that did not permit sufficient lateral control to keep the aircraft on the runway.

2. Flight service station and airport staff did not ensure that the RSC reports were updated and passed to aircrew in changing weather conditions.

3.2 Findings as to Risk

1. The order of the items on the airline's emergency evacuation checklist increases the risk of injuries to passengers during an evacuation because the aircraft may not be configured safely.

2. No airline procedures were in place for passenger survival in harsh climates following an airport passenger evacuation. An evacuation in harsh climates has the potential of injuring passengers, who often are not dressed warmly.

3. The call for the emergency evacuation was not heard in the passenger cabin because the first officer used a microphone and erroneous audio panel switch selection that resulted in the announcement not being heard, thus delaying the evacuation.

3.3 Other Findings

1. All Iqaluit radio frequencies were subject to interference from snow and ice accretion except for 122.6 MHz.

4.0 Safety Action

4.1 Safety Action Taken

4.1.1 First Air

On 27 September 2000, as a result of this occurrence, First Air issued a bulletin to volume 1 of its *Boeing 727 Operations Manual*. Bulletin 88 in part discusses passenger address (PA) announcements made without crews using oxygen masks: "The Passenger Address hand microphone located on the aft portion of the control stand must be used at all other times to accomplish a PA. The Passenger Address hand microphone will allow PA transmission independent of audio panel selections."

First Air's *Boeing 727 Flight Instructor Manual* was amended to describe the procedure and the circumstances for using the hand microphone on the aft portion of the control stand.

First Air issued an engineering order to have the audio selector panels that do not permit PA announcements using the boom or hand microphones modified so that PA announcements can be made using the boom microphone, the hand microphone, or the oxygen mask microphone.

First Air is in the process of amending its Transport Canada–approved emergency checklist to be consistent with Boeing's procedures for emergency evacuation.

4.1.2 Nav Canada

After this occurrence, Nav Canada replaced the antennae at Iqaluit Airport because interference on the frequencies proved to be a recurring problem. This action appears to have rectified the radio interference problem.

4.1.3 Transport Canada

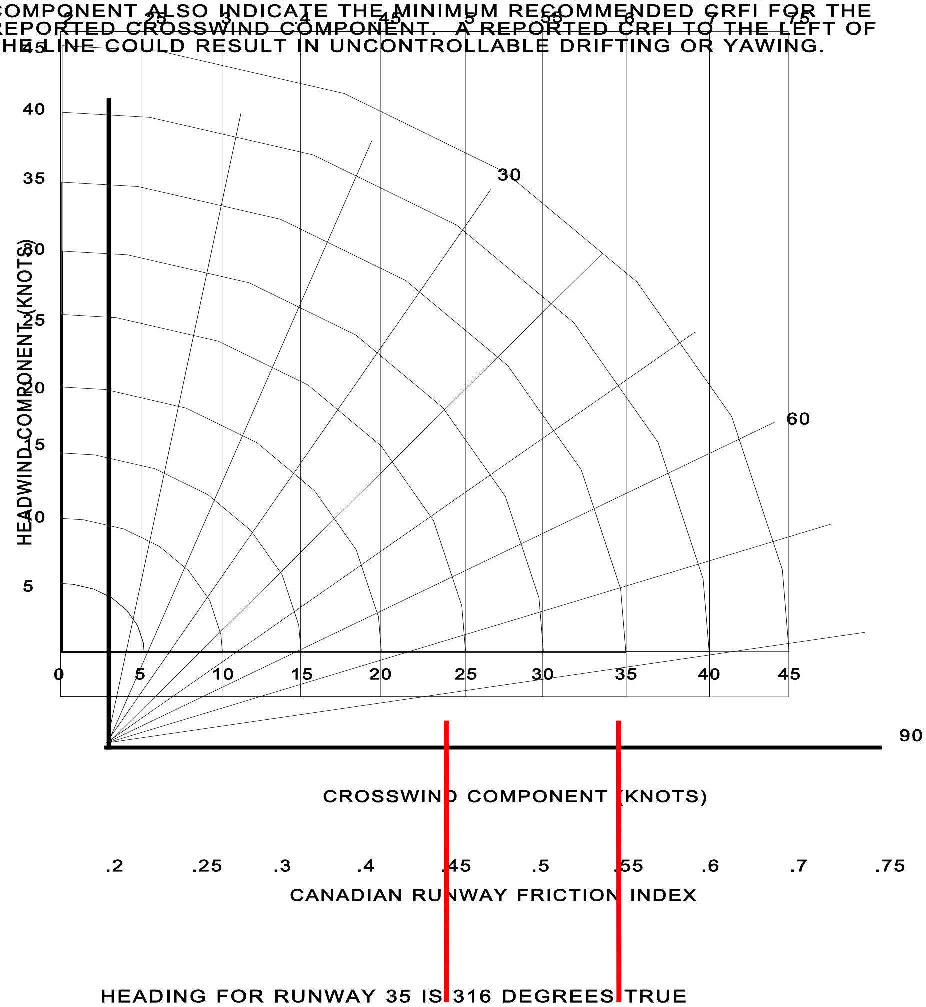
Transport Canada introduced a new standard for airport winter maintenance and planning. *Aerodrome Safety Circular* 2001-11 gave advance notice to industry until the new regulation and standard were in force.

Transport Canada has introduced a regulatory amendment on airport emergency planning, anticipated to be in force in 2002. The new standard will require an airport's emergency plan to include preparation for the types of emergencies, such as passenger evacuation procedures, where airside operations or the safety of individuals are affected.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 13 August 2002.

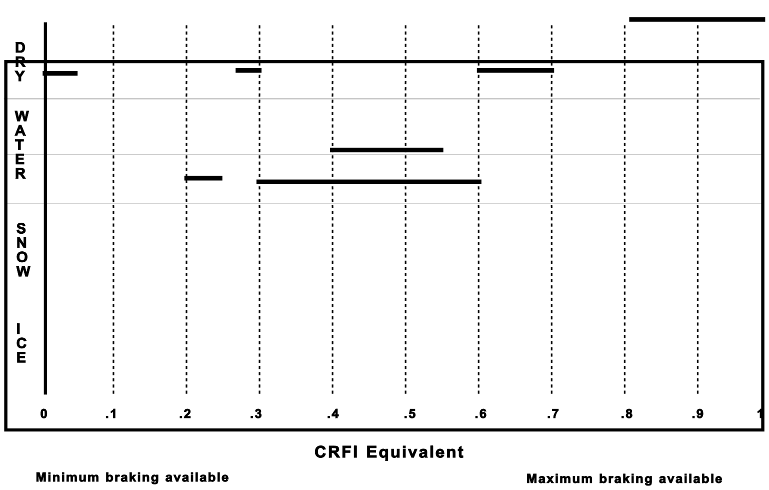
Appendix A—Canadian Runway Friction Index (CRFI)

THIS CHART PROVIDES INFORMATION FOR CALCULATING HEADWIND AND CROSSWIND COMPONENTS. THE VERTICAL LINES OF THE CROSSWIND COMPONENT ALSO INDICATE THE MINIMUM RECOMMENDED CRFI FOR THE REPORTED CROSSWIND COMPONENT. A REPORTED CRFI TO THE LEFT OF THE LINE COULD RESULT IN UNCONTROLLABLE DRIFTING OR YAWING.

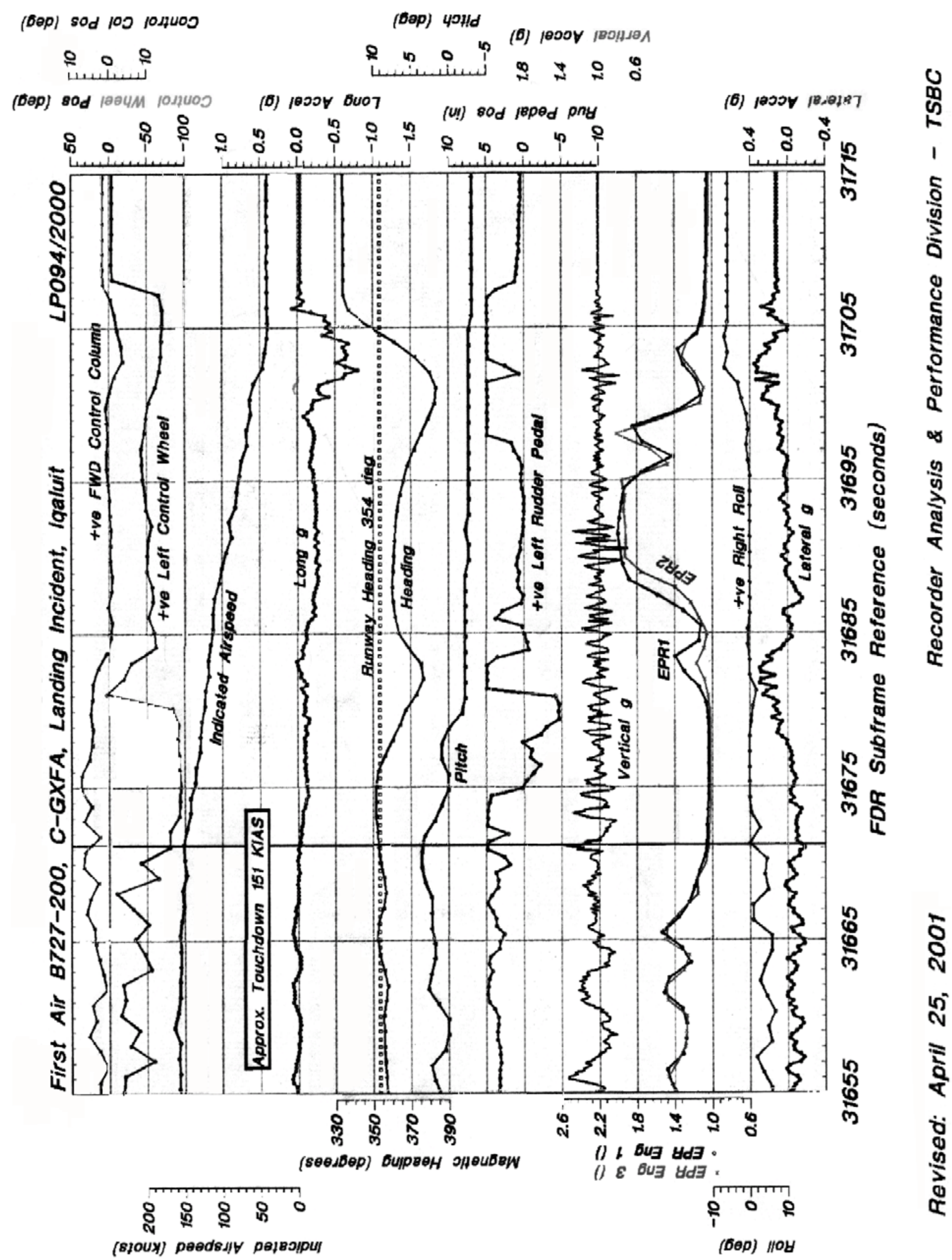


HEADING FOR RUNWAY 35 IS 316 DEGREES TRUE

ACTUAL WIND 050 AT 20 KNOTS GUSTING TO 31 KNOTS



Appendix B1—Flight Data Recorder Information



Appendix B2—Flight Data Recorder Information

Indicated Airspeed (knots)

Appendix C—Glossary

ADIS	automated data interchange system
AFTN	aeronautical fixed telecommunication network
agl	above ground level
asl	above sea level
ATPL	Airline Transport Pilot Licence
AMSCR	Aircraft Movement Surface Condition Report
ASC	*Aerodrome Safety Circular*
AWOS	automated weather observation system
Boeing	Boeing Commercial Aircraft Co.
C	captain
CRFI	Canadian runway friction index
DFDR	digital flight data recorder
DME	distance-measuring equipment
F/E	flight engineer
F/O	first officer
FSS	flight service station
g	G-load factor
HF	high frequency
ILS	instrument landing system
in.	inches
Int	interphone
KIAS	knots indicated airspeed
MHz	megahertz
nm	nautical miles
NOTAM	notice to airmen
PA	passenger address
PIREPS	pilot reports
RSC	runway surface condition
RVR	runway visual range
sm	statute mile
TAF	terminal forecast
TC	Transport Canada
TSB	Transportation Safety Board of Canada
UTC	Coordinated Universal Time
VHF	very high frequency
VOR	very high frequency omnidirectional radio range
°C	degrees Celsius
°M	degrees magnetic
°T	degrees true