Landing short, Air Canada Airbus A320-211 C-FKCO, St. John's, Newfoundland, 24 September 1999

Micro-summary: **This A320 landed short while conducting a non-precision approach in gusty winds.**

Event Date: **1999-09-24 at 0053 NDT**

Investigative Body: **Transportation Safety Board of Canada (TSB), Canada**

Investigative Body's Web Site: **http://www.tsb.gc.ca/**

Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

AVIATION INVESTIGATION REPORT
A99A0131

LANDING SHORT

AIR CANADA
AIRBUS A320-211 C-FKCO
ST. JOHN'S, NEWFOUNDLAND
24 SEPTEMBER 1999

Canada

Aviation Investigation Report

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Air Canada
Airbus A320-211 C-FKCO
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Report Number A99A0131

Summary

The Airbus A320, C-FKCO, operating as Air Canada flight 630, was on a scheduled flight from Toronto, Ontario, to St. John's, Newfoundland. During the night localizer approach to runway 29, which had a relocated threshold, strong gusty winds were encountered. The aircraft touched down approximately 250 feet short of the relocated threshold, striking sawhorse-type construction barriers. The aircraft sustained damage to two brake lines and one brake temperature sensor. There were no injuries to any of the occupants. The aircraft touched down at 0053 Newfoundland daylight time.

Ce rapport est également disponible en français.

Other Factual Information

Runway Environment

Runway 29 at St. John's Airport is 8500 feet long and 200 feet wide. The runway has an average slope of 0.22 per cent; however, slopes vary in the first half of the runway, with some peak values of 0.42 per cent. At the time of the occurrence, the threshold of runway 29 was relocated 1767 feet because of construction. The relocated threshold was marked, in accordance with Transport Canada-approved drawings: flags and cones for daylight operations and four red wing-bar lights on each side of the runway for nighttime operations. Also, two rows of barriers were placed across the unserviceable portion of the runway. These barriers were located 120 and 675 feet, respectively, before the relocated threshold. A notice to airmen (NOTAM) was issued advising that the runway threshold was relocated and that it was marked by flags and cones by day and wing bar lights by night. The NOTAM also listed the high-intensity approach lights as unserviceable. The NOTAM did not mention the barriers. The crew of Air Canada flight 630 (ACA630) had a copy of this NOTAM.

Transport Canada's *Aerodrome Standards and Recommended Practices* (TP312), paragraph 5.3.11.10, states that five wing bar lights are to be used to mark the location of a displaced runway that is more than 45 metres wide. Runway 29 is 61 metres wide. It could not be determined why the use of only four wing bar lights was approved.

Runway 29 was not equipped with a visual approach slope indicator system (VASIS). According to the recommended practice found in TP312, paragraph 5.3.6.2, a VASIS "should be provided to serve the approach to a runway where the runway threshold is temporarily displaced from the normal position and the runway is served by turbojet aeroplanes."[1]

Further, TP312, paragraph 5.3.6.1, states in part that a VASIS shall be provided for normal operations when "terrain or prevalent meteorological conditions are such that the aircraft may be subjected to unusual turbulence during approach." The approach charts for runways 11, 16, and 29 at St. John's Airport all warn of moderate to severe turbulence, yet these runways are not equipped with a VASIS.

The incident occurred after dark on an overcast night. The flight crews from two different aircraft that landed at St. John's Airport that night reported that the approach to runway 29 was like approaching a "black hole".

Transport Canada's *Manual of Instrument Flight Procedures* describes the visual illusion known as "black-hole illusion" as follows:

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[1] TP312 defines recommended practices as follows: "Any specifications for physical characteristics, configuration, material, performance, personnel or procedure; the uniform application of which is recognized as desirable in the interest of safety, regularity or efficiency of air navigation, and to which operators will endeavour to conform. Specifications designated as recommended practices are identified by the verb 'should'."

> During night visual approaches to runways in dark, featureless areas … the lack of ambient clues to orientation interferes with depth perception. Under these conditions, pilots often overestimate their altitude and, while concentrating on maintaining a constant visual angle of approach, … [will fly along a descending] … arc which results in premature contact with the ground.

The Transport Canada publication *Human Factors for Aviation—Basic Handbook* (TP12863) describes visual illusions produced by sloping runways: "On a normal approach to a runway that has even a small uphill slope, you will think that you are too high and will be inclined to descend to make your visual image compatible with the one you are used to."

Weather

Before departure, the crew received an aerodrome forecast for St. John's Airport, issued at 2001[2] on September 23. This forecast indicated that the weather from 2030 on September 23 to 2030 on September 24 would be as follows:

> Surface winds 210 degrees true at 15 knots, visibility greater than six statute miles, cloud level 500 feet scattered, ceiling 2500 feet broken. Temporary fluctuations between 2030 and 0530, visibility four statute miles in light rain showers and drizzle, broken ceilings of 500 feet and 2500 feet, surface wind increasing to 220 degrees true at 25 knots gusting to 35 knots between 2130 and 2330; from 0530, surface winds 250 degrees true at 25 knots gusting to 35 knots, cloud level 1500 feet scattered, ceiling 2500 feet broken.

The aviation routine weather report (METAR) for St. John's Airport valid at 0030 was as follows:

> Wind 250 degrees at 28 knots gusting to 39 knots, visibility 12 statute miles in light drizzle, ceiling 1400 feet overcast.

Environment Canada issued a significant meteorological information (SIGMET) message warning of occasional severe mechanical turbulence below 4000 feet, valid from 0050 to 0450. SIGMETs are sent to control centres, towers, and flight service stations electronically. It was reported that this particular SIGMET was received in the low-level sector of the Gander Area Control Centre at 0052; the St. John's Flight Service Station would have received the SIGMET at the same time. ACA630 would have already progressed by the final approach fix, the "Sierra"[3] beacon, at this time, and advisories of this nature are not normally passed to aircraft at that late stage of an approach.

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[2] All times are Newfoundland daylight time (Coordinated Universal Time minus two and one-half hours).

[3] The distance from the Sierra beacon to the target touchdown zone was approximately 3.3 nautical miles. The elapsed time from the beacon to touchdown was calculated to have been between 1 minute 35 seconds and 1 minute 48 seconds.

While on approach to runway 29, ACA630 received the following weather information from the St. John's Flight Service Station:[4]

0047:27	Winds 260 degrees at 30 knots gusting to 45 knots.
0047:33	Advised of reports of moderate turbulence below 1 200 feet.
0051:22	Winds 260 degrees at 25 knots gusting to 40 knots.
0052:06	Winds 250 degrees at 25 knots gusting to 40 knots.

Flight Data Recorder Information

The aircraft was equipped with an Allied Signal flight data recorder (FDR), model 980-4100-AXUS, serial number 4534. The recorder was forwarded to the TSB Engineering Branch Laboratory for analysis. The FDR data analysis revealed that the aircraft was flown on an autopilot coupled localizer approach to runway 29 until it descended through 550 feet above ground level (agl), about 200 feet above minimum descent altitude (MDA), at which point the autopilot was disconnected. The aircraft was hand-flown by the captain for the remainder of the approach. The approach was uneventful until after descent below the MDA.

After passing the final approach fix, the aircraft descended at a vertical rate of approximately 600 feet per minute (fpm) with an average approach speed of approximately 150 knots calibrated airspeed (KCAS), maintained by the autothrust system, which was in "Speed" mode for the approach. Landing flap of 35 degrees (°) was selected after passing the final approach fix. The flap-35 target approach speed was 139 KCAS. When the autopilot was disconnected in descent through 550 feet agl, the descent was briefly arrested, then re-initiated, continuing below MDA at about 400 fpm. Successive side-stick inputs by the captain during this time, variations in the rate of descent of 100 fpm to 700 fpm, and variations in speed from 142 KCAS to 156 KCAS were consistent with a high level of turbulence being encountered.

In the descent through 150 feet agl, the nose began to pitch up, consistent with nose-up, side-stick input. A maximum 12° of nose-up, side-stick input (3/4 nose-up) was applied, resulting in a corresponding maximum 10° of nose-up elevator deflection. The aircraft's pitch attitude briefly reached about 6° nose-up in the descent through 80 feet agl, as the descent rate peaked at a maximum of approximately 800 fpm. During this time, the captain's side-stick was briefly centred, and then approximately 16° of nose-up, side-stick input (full nose-up) was applied and held for the next four seconds until touchdown. The engine fan speeds increased from about 60 per cent to 74 per cent during the full, nose-up, side-stick application, followed by a further increase to 85 per cent at touchdown.

The aircraft's pitch attitude, which had decreased to 2.6° after the side-stick was centred, increased to about 4° nose-up with the application of full, nose-up side-stick. It was observed that the elevator deflections did not exceed 6° during this time, even though a significantly greater amount of nose-up, side-stick input had been applied. The descent rate (based on radio altitude) remained relatively unchanged at about 700 fpm, and airspeed decreased from

[4] The St. John's Tower was closed at the time of the occurrence; its hours of operation are from 0615 to 2400.

approximately 141 KCAS down to 134 KCAS. The true angle of attack (AOA)[5] reached an average of about 7.5°, where it remained until touchdown. Approaching the runway, the descent was not sufficiently arrested; the subsequent touchdown was hard, with a recorded vertical deceleration of 1.78 g, at 137 knots indicated airspeed (KIAS), and a heading of 286°.

No change in the autothrust system "Speed" mode was observed on the approach until approximately three seconds before touchdown, coincident with an increase of engine fan speeds. This increase in fan speed was the result of crew movement of the thrust levers beyond the climb detent position, to the maximum continuous thrust position just before touchdown. The autothrust system mode changed from "Speed" mode to "Thrust" mode at this time, consistent with the change in the thrust lever position. On previous flights, typical flare initiation occurred from a height of between 30 feet agl and 60 feet agl. The thrust levers were typically retarded to the idle detent at flare initiation, with fan speeds reaching idle settings at touchdown.

Simulations

The TSB requested the assistance of the aircraft manufacturer to determine whether the behaviour of the aircraft was consistent with control inputs and whether any external factors were present. Engineering simulations were carried out based on the landing conditions, approach speed, weight, centre of gravity, and flap configuration. FDR recorded data, including the control inputs, were used to simulate the flight. With no external atmospheric disturbances applied, it was not possible to accurately simulate the known aircraft behaviour. Vertical and longitudinal disturbances (wind gradients) were then estimated to match the behaviour of the aircraft during the occurrence landing. Estimates of the vertical wind below 300 feet agl indicated variations of ± 20 feet per second (fps), and estimates of the longitudinal wind from a height of 100 feet agl to touchdown indicated a decrease in the headwind of 16 fps (10 knots). Vertical trajectory computations performed by the manufacturer indicated that the aircraft remained below a nominal 3° flightpath angle to the relocated threshold during its entire descent, with a steepening of the descent angle below 150 feet agl.

The aircraft is equipped with a high-AOA protection system to prevent exceeding the stall angle during high-dynamic manoeuvres or gust conditions. There are four basic phases or modes to the high-AOA protection system. One such mode is the "Alpha Prot" in which the AOA from side-stick input is converted into AOA demand to protect against aerodynamic stalling. "Alpha Prot" activation depends on several parameters, including AOA where the threshold is 12°. The simulation indicated the activation of the "Alpha Prot" mode, briefly in descent through 220 feet agl, followed by a second activation in descent through 95 feet agl, which then remained active until touchdown. At 220 feet agl, the derived true AOA was approaching the threshold of 12°. The second activation of the "Alpha Prot", which occurred as true AOA was increasing through 3°, likely occurred as the result of a vertical gust, with an estimated magnitude of 10 fps (six knots). As the side-stick was briefly neutralized through 80 feet agl, the elevator positions varied between ± 5°, consistent with control surface deflections in "Alpha Prot" mode.

As full, nose-up, side-stick input was applied and held in descent through 50 feet agl, while in

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5 An AOA refers to the angle between the wing chord and the relative airflow.

"Alpha Prot" mode, the pitch attitude and true AOA reached values of only 7.5° and 4°, respectively. To quantify the effect of the longitudinal wind gradient, which resulted in a seven-knot loss of airspeed below 50 feet agl, the simulation was repeated assuming a zero wind gradient for the final 50 feet of descent. The results indicated that, with a zero wind gradient, the pitch attitude and the true AOA would have reached values of 14° and 10°, respectively, given the full, nose-up, side-stick inputs, and a climb of 40 feet would have been possible, preventing the premature touchdown.

Analysis

The localizer approach to the relocated threshold of runway 29 was described as approaching a black hole. The vertical trajectory computations performed by the manufacturer indicated that the aircraft remained below a nominal 3° flightpath angle to the relocated threshold during its entire descent, with a steepening of the descent angle below 150 feet agl. The runway was not equipped with a VASIS, as was recommended in TP312, and it is probable that the lack of visual cues and a runway-upslope visual illusion during the night approach contributed to the lower-than-nominal flightpath. On this approach, there were no visual glidepath indicators, either internal or external to the aircraft, to assist the crew in maintaining the desired flightpath to touchdown. Also, the high-intensity approach lighting was unserviceable.

The SIGMET warning of severe turbulence was not received by the flight service station specialist until after the aircraft was inside the final approach fix. In accordance with standard procedures, the SIGMET was not passed to the crew of ACA630 at that late stage of the approach. The flight crew, however, had been advised of reports of moderate turbulence five minutes earlier and, after that, had been given two advisories of strong gusting wind. Therefore, even if the crew had received the SIGMET, it is doubtful that they would have done anything different at that stage of the approach.

It was concluded, after analysis of the FDR data, that the aircraft performance met design criteria. The weather conditions were such that the aircraft experienced strong vertical and longitudinal gusts near the ground, likely resulting in a steepening of the descent in the latter stages of the approach. When full, nose-up side-stick was applied to counter the steepening descent, true AOA was limited to less than 8° by activation of the "Alpha Prot" mode to compensate for the decaying airspeed caused by the longitudinal gusts of wind. Despite a substantial increase in engine power being initiated by the crew and the elevators being deflected to the maximum nose-up position allowable in "Alpha Prot" mode, this sudden decrease in headwind close to the ground was such that the descent could not be sufficiently arrested to prevent premature touchdown.

The flight recorder analysis and flight simulation showed that, despite pilot input, the designed aircraft protection systems would not allow the pilot sufficient flight control movement to arrest the descent during the last stages of the approach. Appropriate crew corrective action would have been to initiate a go-around at the point where there was substantial deviation below the desired flightpath; aircraft response to aft side-stick movement became limited by the aircraft protection systems. However, the absence of outside visual cues and the presence of black-hole-illusion conditions would have made it difficult for the crew to assess adequately the aircraft's vertical situation and the rate of change relative to the desired flightpath in sufficient time to recognize that the approach path was significantly low. The crew did not recognize the unsafe condition until it was too late to prevent premature touchdown, as demonstrated by the late advancement of the thrust levers.

The following TSB Engineering Branch Laboratory Report was completed:

LP 105/99—FDR Analysis.

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

Findings as to Causes and Contributing Factors

1. The environment near the runway was conducive to black-hole illusion during the night approach to runway 29.

2. The aircraft was flown below a nominal, three-degree flightpath to the relocated threshold.

3. It is probable that the lack of visual cues during the night approach and runway-upslope visual illusion contributed to the lower-than-nominal three-degree flightpath on the approach.

4. Strong gusting wind conditions caused a sudden loss of head wind near the ground, a corresponding loss of lift, and an increase in the rate of descent.

5. The crew did not recognize the unsafe condition until it was too late to prevent premature touchdown. The absence of visual cues probably contributed to this late recognition of the unsafe condition.

Findings as to Risk

1. The Transport Canada-approved drawings depicting the number of wing bar lights required to mark the location of the displaced threshold were not in accordance with TP312. Consequently, only four wing bar lights were used on each side of the displaced threshold where five were required.

2. A visual approach slope indicator system was not installed to provide guidance for a landing with the displaced threshold. Such an installation is recommended by TP312.

3. The high-intensity approach lighting was unserviceable for runway 29.

Safety Action Taken

The TSB forwarded Aviation Safety Advisory A990041-1 to Transport Canada (TC) in October 1999 informing TC of three landing occurrences on runways with displaced thresholds where the absence of a visual approach slope indicator system (VASIS) may have contributed to the occurrence. This advisory offered that, inasmuch as the current "recommended practice" is not mandatory, TC may wish to consider means of further encouraging or requiring the installation of a VASIS for temporarily displaced thresholds. This advisory also offered that, since a VASIS is recognized in TP312 as being necessary for the safety of air navigation when certain conditions are prevalent, such as turbulence, TC may also wish to reassess the VASIS requirements for normal operations for the runways at St. John's Airport.

TC responded to the letter as follows:

> The Department supports the recommended corrective action of this advisory to broaden the application of visual approach slope indicator systems. In advance of a complete regulatory review of the aerodrome standards being undertaken by the Civil Aviation directorate, a recommendation will be made to the Part III CARAC [Civil Aviation Regulation Advisory Council] committee to upgrade TP312 paragraph 5.3.6.2 from a recommendation to a standard.
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> Regional Managers of Aerodrome Safety have been advised of the concerns raised by this advisory and are requested to consider these findings while processing the approval for airport plans of construction.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 04 April 2001.