Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

AVIATION INVESTIGATION REPORT
A05W0010

FAILURE TO REMAIN ON THE RUNWAY
(REJECTED LANDING)

JETSGO McDONNELL DOUGULAS DC-9-83 C-FRYH
CALGARY INTERNATIONAL AIRPORT, ALBERTA
20 JANUARY 2005

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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Summary

The Jetsgo DC-9-83 C-FRYH, serial number 53520, was operating as JGO191 on a flight from Toronto / Lester B. Pearson International Airport, Ontario, to Calgary International Airport, Alberta. The runway visual range passed to the crew with the landing clearance for Runway 34 was 1400 feet, with a runway light setting of five. JGO191 conducted the instrument landing system (ILS) approach and touched down on the runway, left of the centreline at 1956 mountain standard time (MST). The aircraft departed the left side of the runway surface and travelled 1600 feet before climbing out on a missed approach procedure. A hold short sign was struck and destroyed while the aircraft was on the ground. JGO191 was vectored back to Runway 34 for a second ILS approach and landed at 2010 MST. There was minor damage to the aircraft, and there were no injuries among the 78 passengers and 6 crew members.

Ce rapport est également disponible en français.

Other Factual Information

The flight crew were licensed in accordance with the existing *Canadian Aviation Regulations* (CARs). The pilots' flight duty days were within the prescribed regulations and both were rested.

A special weather observation taken at the Calgary International Airport at 1932 mountain standard time[1] was as follows: wind 040° True (T) at 6 knots; visibility ¼ statute mile (sm) in light snow and freezing fog; runway visual range (RVR) for Runway 34, 2800 feet; ceiling 100 feet above ground level (agl). In the remarks section, fog was reported to have 8 oktas[2] sky coverage. The 2000 weather observation was: wind 040° T at 7 knots; visibility ½ sm in freezing fog; ceiling overcast at 400 feet agl; temperature -4°C; dew point -6°C; altimeter 29.74. In the remarks section, fog was at 6 oktas and stratus clouds were at 2 oktas. The RVR for Runway 34 was 1400 feet.

Radar vectors were given to JGO191 to position the aircraft for the Cat I instrument landing system (ILS) 34 approach. Approach clearance was given by Calgary Arrival with an RVR value of 1600 feet. Initial contact with Calgary Tower indicated that the RVR for Runway 34 was 1600 feet. Calgary Tower cleared JGO191 to land with the advisory that the preceding aircraft had reported sighting the approach lights at decision height (DH) (200 feet agl), and that the current RVR value was 1400 feet.

The approach was flown in accordance with the existing CARs. The captain, as the pilot flying (PF), flew from the left seat. The autopilot was engaged and coupled to the ILS receiver, and the auto throttles were engaged, which provided a stabilized approach profile at about 135 knots. The pilot not flying (PNF) monitored the approach from his instruments and called 100 feet above DH and then DH. Periodically, the PNF looked outside the cockpit to identify the runway lights. The PF flew the aircraft with reference to the flight instruments until reaching the DH, where, upon gaining visual reference to the approach lights, he elected to land the aircraft.

At DH (1954:55), the captain looked up and called for a landing. The autopilot was disconnected at 1955:05, approximately 65 feet above aerodrome elevation. The PF rolled into a 10° bank to the left, resulting in a heading change of 5° to the left. The PNF noticed that the aircraft was drifting to the left and advised the PF. The PF acknowledged the PNF and continued with the landing. The aircraft touched down on the runway at 1955:13, approximately 1400 feet from the threshold of Runway 34 and about 80 feet left of the centreline, on a track of about 335° Magnetic (M) (see Figure 1). The aircraft departed the left side of the runway 1600 feet from the threshold, eventually parallelling the runway about 71 feet from the edge.

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

[2] The opacity of the cloud layers is measured in eighths of the sky concealed (oktas).

Take-off power was applied to initiate a go-around at 1955:17. While travelling through the grass, the aircraft's left outer flap struck a glancing blow to the hold short sign located south of Runway 07/25. JGO191 proceeded across Runway 07/25 and struck and destroyed the hold short sign north of Runway 07/25 with the left main landing gear before lifting off at 1955:25. The aircraft was on the ground for approximately 1800 feet and 11.5 seconds.

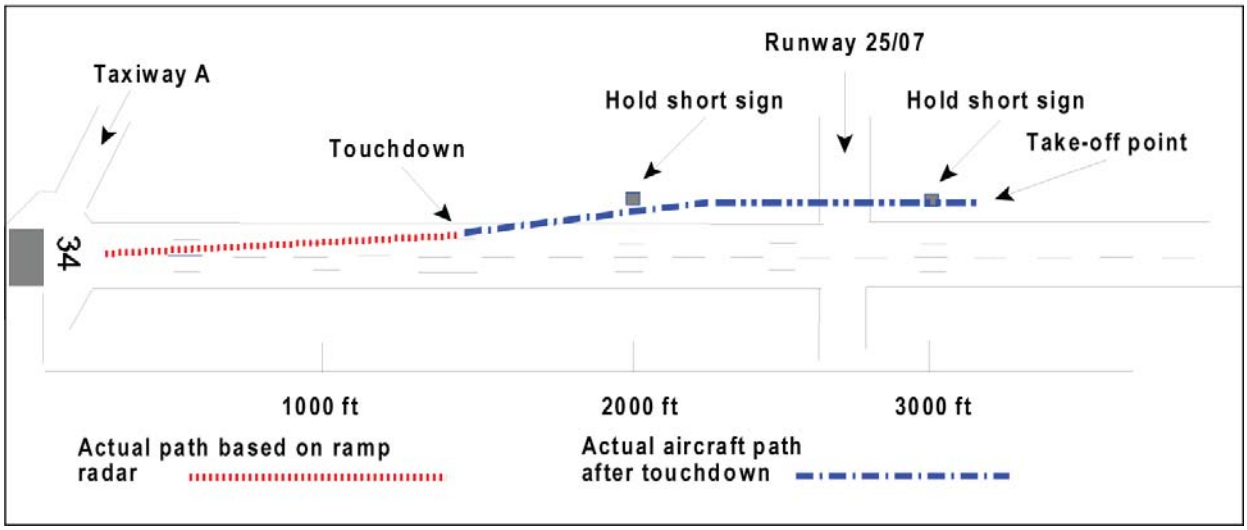

Figure 1. Overhead view of the runway – Calgary International Airport

After the climb out, the crew observed the "Red Light On With Landing Gear Handle Up" indication, which indicated that the landing gear had not successfully retracted. The appropriate checklist items were reviewed and it was determined that, due to undetermined damage to the landing gear, the aircraft would be restricted to 230 knots. The crew elected to conduct a second approach into Calgary due to the speed restriction and the high prevailing winds from the west that would preclude the use of Abbottsford as an alternate.

JGO191 was advised by air traffic services that there were nine aircraft holding ahead and if they could not accept an extended downwind they should plan for their alternate or declare a fuel emergency. JGO191 declared a fuel emergency, with 11 000 pounds of fuel on board, in order to be sequenced to the front of the line. A second ILS approach to Runway 34 was successfully executed. The RVR value on Runway 34 at the time of the second approach was 1400 feet.

Runway 34 was equipped with high intensity runway edge lighting, with variable settings to a maximum of five. The lighting system was comprised of white parallel runway edge lights, green threshold lights, red runway end lights, 1000 feet of sequenced flashing approach lights, and 1400 feet of white runway alignment indicator lights.

Runway 34 was served by a precision Cat I ILS approach. The DH was 200 feet agl with an advisory visibility of ½ mile or 2600 feet. The ILS provided a standard 3° glide slope on a final approach course of 343° M. A NAV CANADA *Navigational Status Report* taken at the time of the occurrence indicated that the ILS readings for Runway 34 were normal. The last flight check of the ILS was conducted on 15 May 2004; the results were within normal parameters.

Runway 34 had an RVR type A sensor located adjacent to the runway threshold. The sensor measures light emitted from its projector to calculate the maximum horizon distance that may be seen from a point above its centreline at a height corresponding to the average eye level of pilots at touchdown.[3] The amount of light detected may be attenuated by snow, fog and rain. The sensor was subject to monthly maintenance inspections. Prior to the occurrence, the sensor was inspected on 27 December 2004 and found to be accurate.

Runways serviced with an RVR are subject to an approach ban (CARs 602.129). The regulation provides the only visibility-based restriction for the conduct of an approach or landing. This allows the pilot to conduct an approach to a runway anytime the RVR is at least 1200 feet, or in cases where the RVR is not available or not provided. Visibility values provided in the *Canada Air Pilot* (CAP) approach plates are advisory only and, if prevailing at the time of approach, should result in the required visual reference being established and maintained to landing. A pilot may continue with a landing provided that visual contact with the runway environment was made prior to passing the minimum descent altitude or DH (see CAP GEN 13).

Canada Air Pilot (CAP) GEN 13

The visual references required by the pilot to continue the approach to a safe landing should include at least one of the following references:

- 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; or
- the runway centreline lights.

Riordan (1974) describes the process through which the pilot acquires and interprets the visual cues available in the runway environment.[4] To assess glide slope and runway closure, the pilot will:

- assess runway perspective: the pilot assesses the size of the runway (which varies with horizontal distance from the runway) and shape of the runway (which varies with vertical distance from the runway);

- assess visual rate of change: the pilot assesses the rate of change of these two variables to provide information with respect to the horizontal closure rate (change of apparent runway size) and vertical position with respect to the glide slope (change of apparent runway shape); and,

- assess runway motion parallax: the pilot uses any apparent motion of the target touchdown point to provide an indication of rate of descent.

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3 *Aeronautical Information Publication*, "Rules of the Air and Air Traffic Services," 9.20.1.

4 R.H. Riordan, "Monocular Visual Cues and Space Perception During the Approach to Landing." *Aerospace Medicine* 45(7) (July 1974), pp. 768-770.

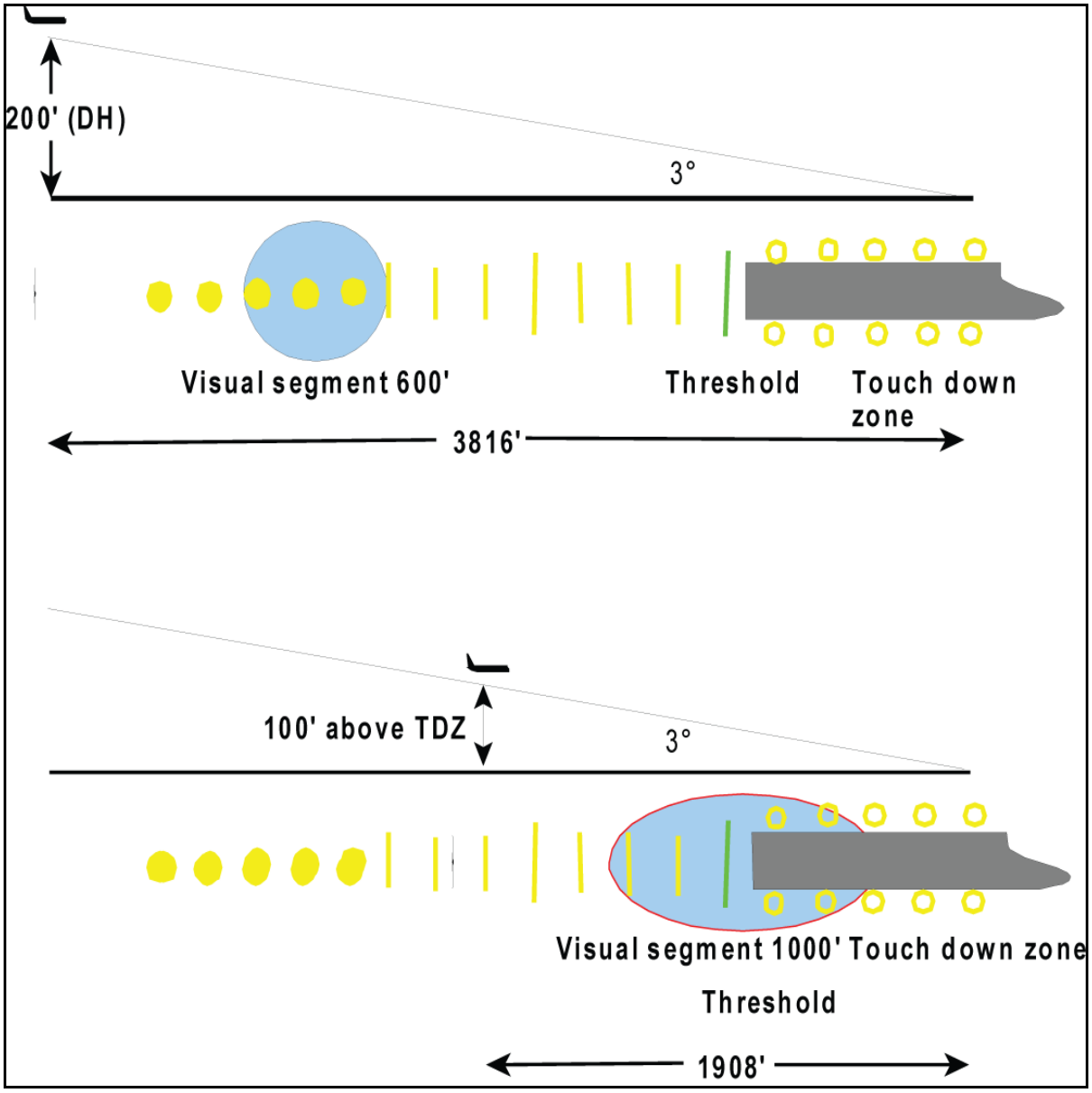

Figure 2. Available visual segment at 200 feet and at 100 feet on an approach

When pilots are making the transition from instrument to visual flight, their ability to judge the approach, flare and landing rollout will be dependent upon the length of the visual segment (that is, the distance ahead of the aircraft that the pilot can see). At a DH of 200 feet, on a 3° glide slope, the aircraft is 3816 feet from the touchdown zone (3816' = 200 ÷ Tan 3°). Carmack (1972)[5] points out that the downward vision angle of most transport aircraft is approximately 14°, which will significantly reduce the length of the visual segment. At a height of 200 feet agl, approximately 800 feet (800 = 200 ÷ Tan 14°) in front of the aircraft will be obscured by the nose of the aircraft, and at 100 feet agl, the amount of obscured terrain will be approximately 400 feet

[5] D.L. Carmack, *Landing Weather Minimums Investigations*. (IPIS-TR-70-3. U.S.A.F. Instrument Pilot Instructor School, Randolph Air Force Base, Texas, 1972). p. 26.

(400 = 100 ÷ Tan 14°). Given a 1400-foot RVR and assuming this to be representative of slant range visibility, this will provide a visual segment at a 200-foot DH of approximately 600 feet, and a visual segment of approximately 1000 feet at 100 feet agl. Carmack summarized the effect of this visual segment as follows: "A visual segment of 800 feet is insufficient to consider as visual conditions, so the aircraft must be flown by instruments below decision height."[6]

In addition to assessing the cues described above, to judge rate of closure and rate of descent, the pilot must have sufficient cues to assess any lateral deviation from the runway centreline and correct for drift. The time required to complete the transition from instruments to visual cues was assessed during the Carmack study. The following is a conclusion from that study:

> It was determined it requires about three seconds for the heads-down pilot to integrate the outside visual cues after becoming visual. It requires this length of time to adjust to the outside environment, to determine position with relation to the runway, determine cross-track rate and develop the knowledge to effect the control inputs necessary for visual control.[7]

The time required for this transition will be increased in situations where the aircraft is offset from the runway centreline at minimums (e.g. during crosswind approaches), or where obscured or partially obscured conditions as visual cues will become indistinct and easily lost in these conditions.[8] Any hesitation in making the transition from inside to outside references will also vastly increase the time required to fully integrate visual cues. Studies have demonstrated that a pilot requires a minimum of 700 milliseconds to transition from outside references to inside references. During this period, the crew member is not capable of attending to information either inside or outside of the cockpit.[9] Therefore, a pilot faced with indistinct visual cues attempting to compensate with reference to the flight instruments will have their cognitive resources taxed significantly during the last moments of the approach.

Hoglund (1982)[10] indicates that the time available for decision making between a 200-foot DH and the threshold on a 3° glide slope would be 19 seconds for an aircraft travelling at 120 knots and 16 seconds for an aircraft travelling at 140 knots. Based on this and the lighting systems available, he recommended "look-see" approaches be prohibited if RVR values were less than 1800 feet for Cat I operations.

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6 D.L. Carmack, p. 51.

7 D.L. Carmack, p. 17.

8 D.L. Carmack, pp. 17, 21.

9 S.G. Hart, "Helicopter Human Factors." In E.L. Weiner and D.C. Nagel (eds.), *Human Factors in Aviation*. (San Diego: Academic Press. 1988.) p. 61.

10 W.O. Hoglund, *Comprehensive Analysis of Weather Minima Standards*. Unpublished consultants report. (TSB Library Call # TL556.H63 1982 C.1). 1982. p. 42.

Young (2003)[11] indicates that a particularly [critical] period for the pilot occurs when making the transition from instrument flight to flying by external visual cues. There is not a specific illusion associated with the transition, but rather a period of uncertainty concerning orientation. A pilot who has been concentrating on the instruments in lining up for a landing may easily experience spatial disorientation during the several seconds after looking up and trying to find the runway and the horizon through broken clouds.

A vection (visually induced perception of self-motion) illusion is produced by the nearly uniform motion of a large part of the visual field, resulting in the person feeling that they are moving opposite to the motion observed in the visual field.[12] Therefore, fog moving across a runway could give a pilot a false sense of drift. However, this illusion will be relatively easily overcome if sufficient stationary cues are available, such as additional lighting. In this occurrence, as described above, the available visual cues were marginal to allow the landing to be carried out effectively, even in the absence of a vection illusion. The presence of moving elements in the visual scene, such as blowing fog or snow, would only compound the problem.

A number of occurrences have been investigated by the TSB in which inadequate visual references during the final stages of an approach contributed to an accident.

- A91A0198: A DC-8 aircraft was conducting an ILS approach to Runway 29 at the Moncton Airport, with a reported RVR of 1400 feet. After touchdown, the aircraft left the right side of the runway and travelled approximately 1100 feet prior to regaining the runway. During the final stages of the landing, the crew had difficulty discerning the runway.

- A93W0037: A Boeing 737 conducting a Category I ILS to Runway 16 at the Calgary Airport departed the left side of the runway after touchdown. The aircraft struck a number of runway and taxiway lights prior to regaining the runway surface. The weather at the time of the occurrence was a ceiling of 200 feet obscured and a visibility of ⅛ mile in very light freezing drizzle and fog. The RVR was reported to the crew as 2400 feet; runway lights were switched to a setting of five just prior to commencing the approach.

- A97H0011: A Canadair CL 600 Regional Jet was conducting a Category I ILS approach to Runway 15 at the Fredericton Airport. The crew had sight of the approach lights at minimums and elected to land. On arrival, the reported ceiling was 100 feet obscured, the visibility ⅛ mile in fog, and the RVR 1200 feet. On reaching about 35 feet, the captain assessed that the aircraft was not in a position to land safely, as it was left of the centreline and the crew had no way to assess how far down the runway they were; the captain ordered a go-around. As the aircraft reached its go-around pitch attitude of about 10°, the aircraft stalled aerodynamically and impacted the ground.

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[11] L.R. Young, "Spatial Orientation." In P.S. Tsang and M.A. Vidulich (eds.), *Principles and Practice of Aviation Psychology*. (New Jersey: Lawrence Erlbaum Associates. 2003.) p. 95.

[12] L.R. Young, p. 98.

- A99Q0151: A Raytheon Beech 1900D was on a scheduled flight from Port-Menier to Sept-Îles, Quebec, with two pilots and two passengers on board. The aircraft crashed while on approach to the airport, 1 nautical mile (nm) short of the runway, in reported weather conditions of a 200-foot ceiling and ¼ sm visibility. The crew had descended well below safe minimum altitude while in instrument meteorological conditions.

- A03Q0151: A PA-31-310, with one pilot and two passengers on board, was on a visual flight rules flight from Îles-de-la-Madeleine, Quebec, to Gaspé, Quebec. While en route to Gaspé, the pilot was informed that weather conditions at his destination were a ceiling of 500 feet and visibility of ¾ sm in fog. The wreckage was found on a hilltop 1.2 nm northeast of the airport. The pilot had continued his descent below minimum descent altitude without having the visual references required to continue the landing.

- A04W0032: A Boeing 737 aircraft was conducting an ILS approach to Runway 15 in Edmonton, in conditions of freezing fog with a reported RVR of 1200 feet; runway lights were at a setting of five. The aircraft touched down to the left of the runway and travelled approximately 1600 feet before returning to the runway.

These occurrences share a number of commonalities. All were conducted during darkness with visibilities less than those recommended on the CAP approach plate to runways served by a Category I ILS system. In these occurrences, the crew had sight of the runway environment at minimums and elected to land, but subsequently had difficulty acquiring sufficient visual references to maintain aircraft alignment with the runway.

The Transportation Safety Board has identified safety deficiencies associated with conducting approaches in low visibilities. As a result of investigation A97H0011, TSB Recommendation A99-05 was issued, advising the following:

> The Department of Transport reassess Category I approach and landing criteria (re-aligning weather minima with operating requirements) to ensure a level of safety consistent with Category II criteria.

In its 06 August 1999 response to TSB Recommendation A99-05, Transport Canada indicated that draft regulatory amendments to strengthen the standards for instrument low-weather approaches would be submitted without delay to the Canadian Aviation Regulatory Advisory Council for consultation, with the goal of implementing changes as soon as possible.

On 12 August 1999, another accident occurred where approach visibilities were identified as an underlying factor (A99Q0151). As a result of the investigation, TSB Recommendation A02-01 was issued, which stated in part:

> From January 1994 to December 2001, the Board has investigated 24 such accidents where low visibilities and/or ceilings likely contributed to the accident. 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.... This process has been ongoing for two years now; however, its timely implementation has been delayed because of some resistance.

The Board recommended 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.

In its 26 May 2002 response, Transport Canada indicated that it had prepared 16 Notices of Proposed Amendments (NPAs) to address TSB Recommendation A02-01, concerning approach ban regulations related to visibility. These NPAs were under review at the Department of Justice at the time, and it was expected that the final product would be published in the June 2002 issue of the *Canada Gazette*.

On 25 November 2004, the Board released report A03Q0151, which identified that Transport Canada's proposed approach ban regulatory initiative should decrease the probability of accidents on instrument approaches in reduced visibility conditions. However, the report further stated that, "The Board was nonetheless concerned that, until these proposed regulatory provisions come into force, safety measures will remain inadequate against the risk of controlled flight into terrain resulting in loss of life."

The drafted NPAs were published in the *Canada Gazette, Part I,* in November 2004 for comment. The period for comment ended in January 2005. Transport Canada is in the process of reviewing these comments and the Board will continue to monitor the progress of these amendments.

The proposed changes to the approach ban regulations would include an increase from RVR 1200 to RVR 1800 for Category I precision approaches servicing runways without centreline lighting for commercial operations. For airline operations (CAR 705), authorized through an Operations Specification requiring additional training requirements and aircraft and aerodrome equipment requirements, the required RVR would be 1200 for a HUD (head-up display) equipped aircraft, or 1600 for a non-HUD equipped aircraft.

Analysis

All aircraft, airport and NAV CANADA facilities were operating as designed, and were fully functional at the time of the occurrence. The analysis will focus on reasons why visual references were lost at a critical time in the approach, and the risks associated with conducting approaches in runway visual range (RVR) 1400 weather to a Category I runway.

The captain continued the approach as he visually acquired the runway environment. During the transition to the visual environment, difficulty was encountered in orienting the aircraft to the runway. Given the weather conditions at the time of the occurrence, it is possible that freezing fog swirling around the aircraft could have created the illusion of movement about the aircraft. While the prevailing visibility was above the minimum value allowed to conduct an approach, the effective visibility due to the downward vision angle was approximately 600 feet at decision height. Even as the aircraft continued in the descent, forward visibility at 100 feet above ground level would have only increased to 1000 feet under ideal conditions. The 10° bank to the left at 65 feet, in combination with the reduced forward visibility, impeded the pilots' ability to judge the aircraft's orientation to the runway. As a consequence, the aircraft touched down left of the centreline and ran off the edge of the runway.

The approach was conducted in accordance with current Transport Canada regulations and, as such, demonstrates that the visual aids associated with a Category I approach were less than adequate to maintain directional control during RVR 1400 operations.

The following TSB Engineering Branch project was completed:

LP 008/2005 – CVR/FDR Analysis

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

Findings as to Causes and Contributing Factors

1. There were insufficient visual cues during the landing phase to enable the pilots to judge the aircraft's orientation to the runway. As a result, the aircraft landed left of the centreline and failed to remain on the runway.

2. The current regulations allow for approaches and landings to be carried out in low visibility, increasing the risk of an ineffective transition to visual flight.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 05 October 2005.

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