Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

AVIATION INVESTIGATION REPORT
A11Q0170

RISK OF COLLISION

SKY REGIONAL AIRLINES INCORPORATED
DE HAVILLAND DHC-8-402 C-FSRY
AND
PROPAIR INCORPORATED
BEECH A100 KING AIR C-GJLJ
MONTRÉAL/PIERRE ELLIOTT TRUDEAU INTERNATIONAL AIRPORT, QUEBEC
29 AUGUST 2011

Canada

Aviation Investigation Report

Risk of Collision

Sky Regional Airlines Incorporated de Havilland DHC-8-402 C-FSRY and Propair Incorporated Beech A100 King Air C-GJLJ Montréal/Pierre Elliott Trudeau International Airport, Quebec 29 August 2011

Report Number A11Q0170

Summary

A Bombardier DHC-8 (registration C-FSRY, serial number 4174) operating as Sky Regional Airlines Incorporated flight SKV7516 departed Toronto, Ontario, and landed on Runway 24R at Montréal/Pierre Elliott Trudeau International Airport, Quebec. The aircraft crew was then instructed by the ground controller to taxi on Taxiway Echo and hold short of Runway 28; SKV7516 read the instructions back correctly. As SKV7516 entered Taxiway Echo, the airport controller cleared a Beech A100 King Air (registration C-GJLJ, serial number B-235) operating as Propair Incorporated flight PRO104 to take off from Runway 28. Approximately 2 minutes later, SKV7516 reached the hold line of Runway 28, and entered Runway 28 without stopping. PRO104, which was approaching rotation speed, aborted take-off as soon as it saw SKV7516 on the runway. PRO104 veered to the right of the runway centreline and passed about 40 feet behind SKV7516. The occurrence took place during daylight hours at around 1533 Eastern Daylight Savings Time.

Factual Information

History of the Flight

Sky Regional Airlines Incorporated flight SKV7516, a Bombardier DHC-8, took off from Billy Bishop Toronto City Airport, Ontario, on a scheduled flight bound for Montréal/Pierre Elliott Trudeau International Airport, Quebec, with 4 crew members and 25 passengers on board. When the flight left Toronto, the first officer, who was sitting in the right-hand seat, was at the controls. The aircraft touched down on Runway 24R at 1530:20 [1] after an uneventful flight. At 1530:31, the airport controller instructed SKV7516 in English to exit the runway on Taxiway Echo and to hold short of Taxiway Bravo, and then to contact ground control. On the runway, the captain took the controls, [2] then exited to the left on Taxiway Echo (Figure 1).

At 1530:50, the airport controller cleared Propair Incorporated flight PRO104, a Beech A100 King Air, to take off from Runway 28. As permitted by the *Canadian Aviation Regulations* (CARs), communications between PRO104 and air traffic services (ATS) were in French. [3] At this time, the aircraft was on Alpha, abeam Alpha 2, some 1200 feet from the threshold of Runway 28. [4] PRO104 was preparing to conduct a check ride with 2 pilots and 1 check pilot on board.

At 1530:57, the ground controller instructed SKV7516 to give way to an Embraer (ACA187) before continuing to taxi on Taxiway Echo, and to hold short of Runway 28. The Embraer was taxiing in the opposite direction on Taxiway Echo, allowing it to use Taxiway Bravo eastbound. The first officer repeated the instruction as required. The purpose of a readback is to ensure that crews receive an instruction correctly. The aircraft slowed almost to a stop, allowed the Embraer to pass, and then resumed taxiing at a ground speed of approximately 17 knots.

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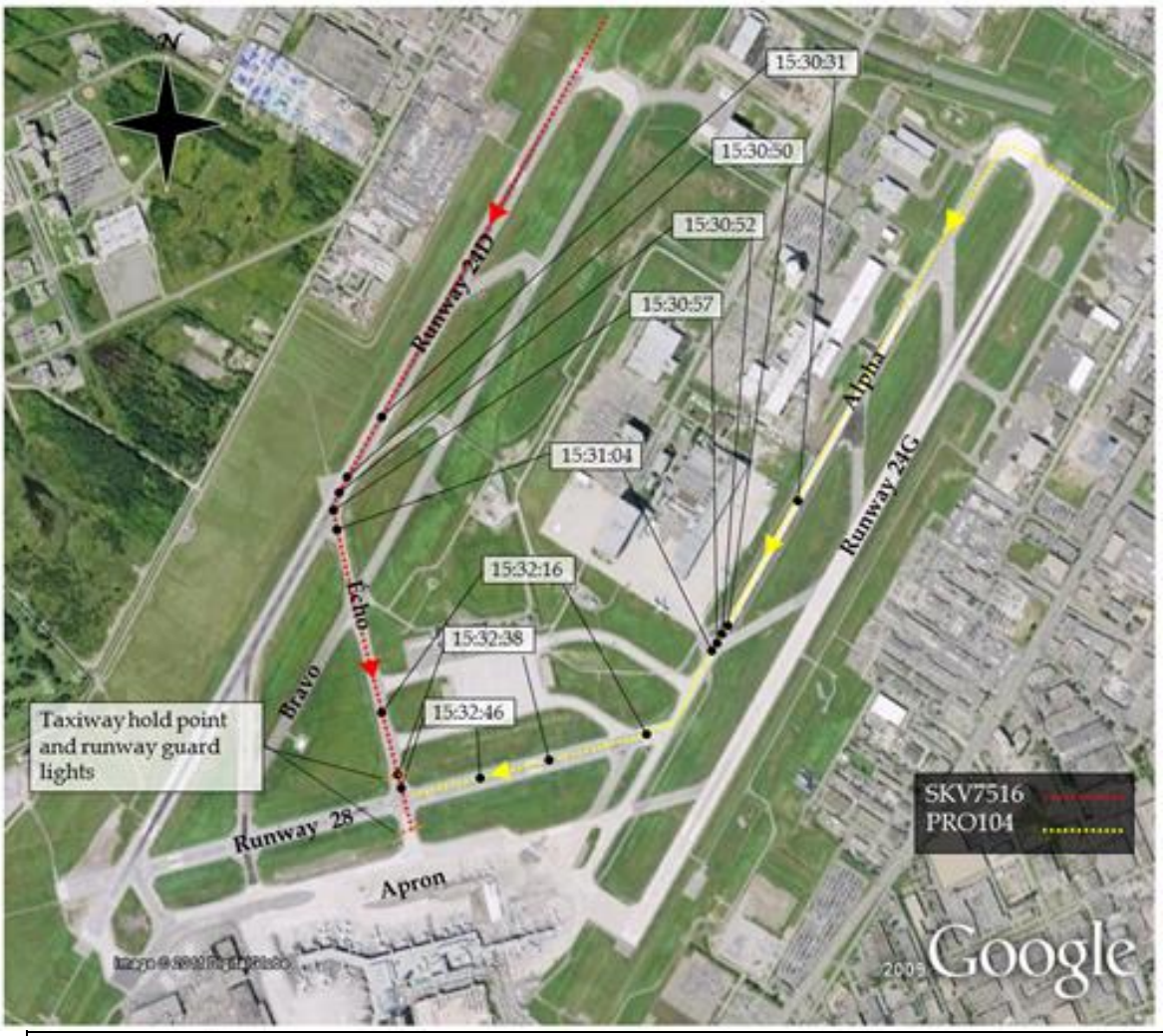
1 All times are Eastern Daylight Savings Time (Coordinated Universal Time minus 4 hours).

2 The nose wheel steering control was on the captain's left.

3 Provisions regarding the use of French and English in aeronautical radio communications are set out in *Canadian Aviation Regulations* (CARs) 602.133, 602.134, and 602.135.

4 The hold line of Taxiway Alpha for Runway 28 lies approximately 850 feet from the runway threshold at the exit of Taxiway Alpha Charlie.



1530:31 – Tower instructs SKV7516 to hold short of Bravo and contact ground

1530:50 – Tower clears PRO104 to take off from Runway 28

1530:52 – SKV7516 informs ground taxiing on Echo short of Bravo

1530:57 – Ground instructs SKV7516 to give way to ACA187 and then taxi on Echo and hold short of Runway 28

1531:05 – SKV7516 confirms hold short of Runway 28

1532:16 – SKV7516: 17 knots; PRO104: 7 knots

1532:38 – SKV7516 crosses hold point at 17 knots; PRO104: 66 knots

1532:46 – SKV7516 enters runway; PRO104: 93 kts

Figure 1. Aircraft trajectories and timeline of air traffic control communications

At 1532:16, PRO104 reached the threshold of Runway 28. The flight crew switched on the landing lights, and without coming to a standstill, the aircraft continued its momentum to begin take-off. At this time, the flight crew of SKV7516, which was some 650 feet from the hold line of Runway 28, visually scanned the runway. The first officer indicated that the runway was clear to the right of the aircraft, and the captain did the same for the part of the runway to the left. At 1532:38, SKV7516 crossed the taxi hold-position line at a ground speed of 19 knots. PRO104, accelerating at 85 knots, was then some 1200 feet from Echo. The flight manual does not specify

a rotation speed, but Propair has set take-off speed at 100 knots. Approximately 6 seconds later, PRO104 aborted its take-off at 102 knots and braked heavily.

At 1532:46, the ground controllers and airport controllers simultaneously observed that SKV7516 was about to cross the runway. The ground controller ordered the crew to stop, while the airport controller only transmitted the SKV7516 call sign. At about the same time, the DHC-8 contacted the apron management service (AMS) and continued travelling straight ahead, crossing the runway. The decelerating King Air veered to the right of the runway centreline and passed at 37 knots, about 40 feet [5] behind SKV7516 , which was crossing the runway centreline at 16 knots. Ground control attempted in vain to contact SKV7516. A few seconds later, the DHC-8 contacted ground control after being requested to do so by AMS.

Post-occurrence Information

In the moments following the risk of collision, the PRO104 flight crew decided to resume take-off without delay. [6] The aircraft returned to the threshold of Runway 28 and took off. The flight was uneventful, landing was normal, and taxiing to the company's base was carried out without incident. However, the post-flight inspection of the aircraft revealed damage to the outside left tire and a slight leak of brake fluid from the left side.

Neither the aircraft flight manual, the Beechcraft maintenance manual, nor Propair provides any information about possible damage to the landing gear or braking system following a rejected take-off (RTO), nor do they mention any measures to be taken following heavy braking.

Information on the Aerodrome

Aéroports de Montréal (ADM), a non-profit organization, operates Montréal/Pierre Elliott Trudeau International Airport in accordance with the standards set out in the Transport Canada (TC) publication *Aerodromes Standards and Recommended Practices* (TP 312).

The airport has 2 parallel runways (Runways 06L/24R and 06R/24L), a crossing runway (Runway 10/28), numerous taxiways, and several aprons [7] (Figure 1). Taxiway Echo crosses Runway 28 at about 3000 feet from the runway threshold. At the time of the occurrence, Runway 24L was closed for construction. Runway 24R was used for take-offs and landings, and Runway 28 was used for take-offs. The main apron, where the aeroquay and air terminal are located, lies about 450 feet south of Runway 28. Consequently, aircraft coming from Runway 24R must cross Runway 28 in order to reach their gates.

The number and layout of runways and taxiways can have a significant impact on the risks of runway operations. Mid-runway incursions pose an extremely serious risk, because they occur at a place where aircraft are being operated at high energy levels.

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5 Taking into account the size of the wings and fuselage of both aircraft

6 The pilot check ride had been postponed 3 times.

7 An apron is part of an aerodrome, other than the manoeuvring area, used for passenger and freight loading and unloading operations, refueling, and maintenance and parking of aircraft, as well as for aircraft, vehicle, and pedestrian manoeuvres necessary for these purposes.

Markings and Signage

The taxi hold lines on Taxiway Echo are located at about 300 feet on either side of the centreline of Runway 28, [8] and are reinforced by the presence of runway guard lights (WIG WAG) comprising 2 pairs of yellow lights positioned on either side of the taxiway, flashing alternately when the runway is in service. This device was switched on and operating normally at the time of the occurrence. The intersection of Taxiway Echo and Runway 28 has never been identified as a hot spot. [9] In ADM's assessment, the number of runway incursions (2 in the past 2 years) at the intersection of Taxiway Echo and Runway 28 does not justify designation of the intersection as a hot spot or installation of stop bars. [10]

Air Traffic Control Equipment

The airport is equipped with airport surface detection equipment (ASDE), in addition to a multi-static dependent surveillance (MDS) system [11] that allows tracking of aircraft and vehicle movements on the airport's manoeuvring areas. The ASDE was operating on the day of the occurrence.

The airport does not have a RIMCAS (runway incursion monitoring and collision avoidance system). RIMCAS is an information system designed to monitor surface movements at an airport and in the neighbouring airspace in order to identify potential conflicts between aircraft and other objects in predetermined areas of the airport's surface. The information system can also generate an alarm whenever an aircraft crosses a designated virtual stop bar for taxiways and runways or for designated restricted areas. It alerts only the controllers, without any direct signals to pilots.

As a result of the Transportation Safety Board (TSB) investigation into occurrence A07O0305, a Board Safety Concern [12] regarding the limitations of ASDE and RIMCAS was issued, stating the following:

> It is, however, unclear whether even an improved ASDE/RIMCAS can significantly reduce the risk of runway incursions and their potentially

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8 The location of hold line markings complied with the distances specified in Transport Canada (TC) *Aerodromes Standards and Recommended Practices* (TP312E, 4th edition, 1993, revised 03/2005).

9 A hot spot refers to a point in the movement area of an aerodrome where a collision or runway incursion has taken place and where pilots and drivers must exercise greater vigilance. Source: International Civil Aviation Organization [ICAO] Document 9870, *Manual on the Prevention of Runway Incursions* (2007), Glossary, available at http://cfapp.icao.int/fsix/_Library/Runway%20Incursion%20Manual-final_full_fsix.pdf (last accessed on 13 November 2013)

10 Stop bars are located across the taxiway at the point where it is desired that traffic stop. Source: *Transport Canada Aeronautical Information Manual* (TC AIM), TP 14371E (18 October 2012), Section 7.14 − Stop Bars, available at http://www.tc.gc.ca/publications/en/tp14371/pdf/hr/tp14371e.pdf (last accessed on 13 November 2013)

11 Multi-static dependent surveillance (MDS) technology uses multiple sensors to triangulate an aircraft's position based on signals emitted by the aircraft transponder.

12 TSB aviation investigation report A07O0305 (released 03 November 2009), Safety Action: Safety Concern, page 11

catastrophic outcomes. The improved system will continue to rely on the interpretation of warnings by controllers and their subsequent radio communication with aircraft and vehicles. The provision of warnings directly to flight crews provided the impetus for the current testing and introduction of the runway status light (RWSL) system by the Federal Aviation Administration at some airports in the United States.

However, the need for such a system to supplement ASDE/RIMCAS has not been recognized by either Transport Canada or NAV CANADA. The Board is therefore concerned that until flight crews in aircraft that are taking off or landing receive direct warnings of incursions onto the runway they are using, the risk of high-speed collisions will remain.

Air Traffic Services

Air traffic control (ATC) services at Montréal/Pierre Elliott Trudeau International Airport are provided by NAV CANADA. The control tower provides control services on the manoeuvring area [13] and to aircraft in flight in the control zone.

ADM provides an AMS in the main apron area. An agreement reached between ADM and NAV CANADA provides for coordination between the control tower and AMS.

At the time of the occurrence, SKV7516 was under ground control, while PRO104 was under the control of the airport controller. [14] Three hundred feet after crossing the runway, SKV7516 came under the responsibility of AMS on frequency 122.075 megahertz (MHz).

Air Traffic Control Service

At the time of the occurrence, control staff was comprised of an airport supervisor, a ground controller, and an airport controller. Control personnel staffing was in compliance with NAV CANADA policy, and the controllers had the qualifications necessary to perform their duties.

The control tower situated above the airport terminal is almost opposite and south of Taxiway Echo. There was no obstacle that could interfere with the controllers' field of vision. Both aircraft were visible from the tower at all times.

All communications recorded between PRO104, SKV7516, and Montréal air traffic control were of good technical quality, which indicates that the recording equipment functioned normally and the sound quality was good. All communications were well understood by ATC and by the crews of the 2 aircraft. Air traffic controllers must enforce the rules, procedures, and minimum separation that are stated in the NAV CANADA *Air Traffic Control Manual of Operations* (ATC MANOPS). The ground controller authorized SKV7516 to taxi in compliance with section 346.3

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13 The manoeuvring area is part of the airport used for aircraft take-off and landing, and for ground manoeuvres related to take-off and landing, excluding traffic areas.

14 Ground control was on frequency 121.9 megahertz (MHz), and the airport controller was on the tower frequency of 119.9 MHz.

of ATC MANOPS (Figure 2). The ground controller was not required to advise SKV7516 that PRO104 had been cleared to take off from Runway 28. Traffic information set out in part D of section 346.3 is provided only if the controller deems it appropriate.

Before clearing PRO104 to take off, the airport controller had checked that the runway and the protected area of the runway were or would be free of all traffic. [15] Just before the aircraft began its take-off, SKV7516 was some 650 feet from the hold line. The airport controller had seen the

DHC-8, but expected the aircraft would hold short of the runway. The ground controllers and airport controllers noticed at the same time that SKV7516 had crossed the hold line and was about to cross the runway. Both called SKV7516 on their respective frequencies at the time of the runway incursion. Neither call was received by SKV7516.

Issue taxi authorization, to an aircraft has exited the runway in use, in the following form:

A. (Aircraft identification).

B. (Unit identification if required).

C. TAXI or CONTINUE TAXI, VIA (route) TO (destination or other location), CROSS RUNWAY (number) or HOLD (position or direction relative to a position, runway, taxiway, other) or GIVE WAY TO (description and position of other aircraft or vehicle).

D. (Special instructions or information such as traffic or airport conditions).

Figure 2. NAV CANADA *Air Traffic Control Manual of Operations* (ATC MANOPS), paragraph 346.3

Information on Communications and Use of Radio Frequencies

The audio recordings allow determination of the radio frequency used by the flight crew of each aircraft during the occurrence (Figure 3). However, the audio recordings do not allow determination of the exact time of frequency changes on board aircraft. Consequently, the investigation was unable to identify the frequency to which SKV7516 was tuned at the time when the airport controller cleared PRO104 to take off from Runway 28.

15 NAV CANADA, *Air Traffic Control Manual of Operations* (ATC MANOPS) section 308.2, Visual Scanning – Manoeuvring Area

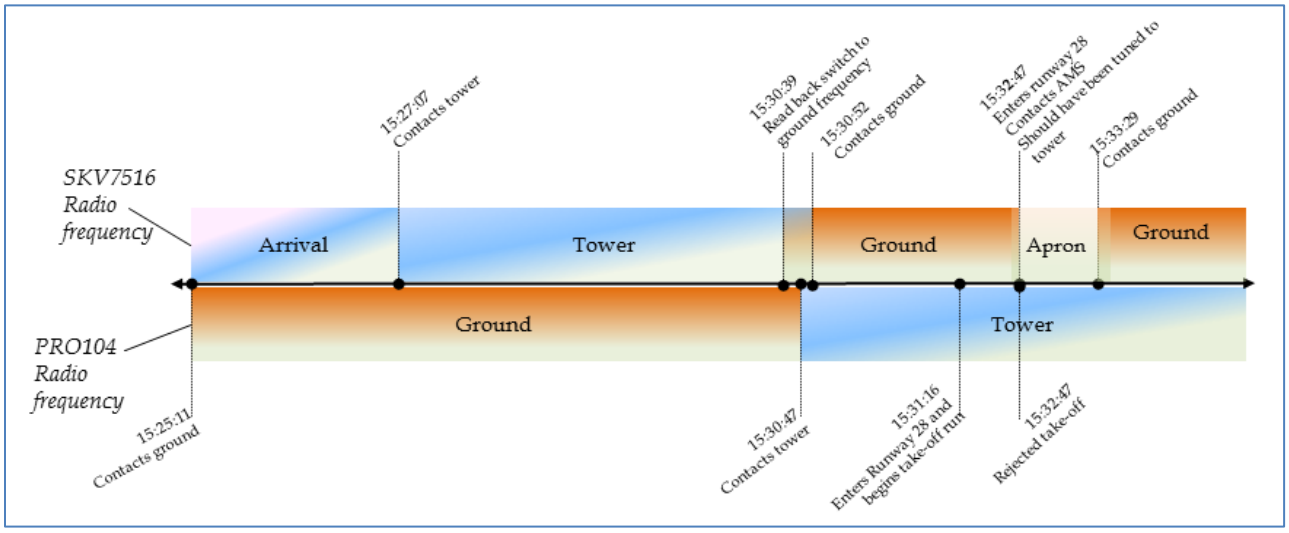

Figure 3. Radio frequencies used by the aircraft

SKV7516 should have progressively switched from the airport controller to the ground controller and finally to the AMS. The ground controller is responsible for all movements of ground traffic on manoeuvring areas. The synchronization of ASDE and ATC recordings confirmed that SKV7516 was tuned to the AMS radio frequency when it crossed Runway 28. Given that an aircraft is not deemed to have left the runway until all of its parts have crossed the taxi hold line, located 200 feet from the edge of the runway, SKV7516 should still have been tuned to the ground control frequency. Furthermore, in accordance with the company's standard operating procedures (SOPs), SKV7516 should also have remained tuned to the airport frequency when it crossed the runway.

Meteorological Information

Meteorological conditions were conducive to visual flight. The wind was from 260° Magnetic at 13 knots, and visibility was 30 statute miles, with a few clouds at 5500 feet and 7500 feet and scattered cloud at 24 000 feet.

Flight Crew Information

SKV7516 Flight Crew

The SKV7516 flight crew was certified and qualified for the flight in compliance with existing regulations. Neither of the 2 pilots spoke or understood French. Nothing in the work and rest schedules of the 2 crew members suggests that fatigue can be considered as a contributing factor in this occurrence.

Since Toronto/Montréal is the only route operated by Sky Regional, the carrier's crews are familiar with the features of Montréal/Pierre Elliott Trudeau International Airport. A typical day for a crew consisted of 2 rotations to Montréal. Generally, flights ended in Montréal by landing on Runway 24R with an exit on Taxiway Echo, followed by an instruction to cross Runway 28 without restriction. The flight in question was typical of other flights, with the exception that the aircraft was to stop before Runway 28 and await instruction to continue on to gate 2.

Once the aircraft was on Taxiway Echo, the flight crew's usual tasks were somewhat interrupted by the Embraer (ACA187) taxiing in the opposite direction. The crew members delayed completing the post-landing checklist until they had passed Bravo. While the crew was receiving the ground controller's instruction to hold short of Runway 28, the 2 pilots were concentrating on the Embraer. The Captain was busy adjusting the taxi lights, [16] and did not pay attention to the ground controller's instructions. After resuming taxiing, the first officer concentrated on the normal checks in the cockpit. Once they reached the Runway 28 hold line, the first officer did not remember that the aircraft had been instructed to hold short, but instead believed that they were authorized to cross it. The crew was unaware that PRO104 had been cleared to take off, and didn't notice the King Air on Runway 28. It was not until some days after the occurrence that the pilots were informed of the risk of collision.

PRO104 Flight Crew

The flight crew comprised a captain and a first officer. A check pilot seated behind the pilots was evaluating instrument flight rules (IFR) proficiency. The pilots were licensed and certified for the first officer's flight as part of a pilot proficiency check (PPC) and under existing regulations.

The first officer was at the controls. Before employment with Propair, the first officer had been an instructor on the ground and on simulators with Bombardier. During service with Bombardier, a recurring simulator drill involved reproducing a runway incursion with a second aircraft during take-off. The purpose of the exercise was to teach the trainee pilot to notice and quickly react to the unauthorized presence of an aircraft on the runway.

The first officer did not notice SKV7516 at the time that PRO104 began its take-off run. The first officer saw SKV7516 as the latter was about to advance onto the runway. The circumstances of the runway incursion were similar to the scenario reproduced in the simulator. The first officer immediately rejected the take-off. The captain was busy monitoring the engine parameters and anemometer, and did not see SKV7516. The check pilot could not see the other aircraft.

Visual Scanning Technique

The human field of vision includes foveal and peripheral vision. Foveal vision is in the centre of the field of vision and is relatively small. It provides visual acuity or, in other words, the perception of details. Outside of this central, cone-shaped area of vision, details are not perceived. Peripheral vision is mainly characterized by the ability to detect movement and changes in luminosity.

Detecting the presence of a distant aircraft normally requires foveal vision, given the size of the object, which is why visual scanning is needed to bring foveal vision into the entire field of vision. Focusing the eye is also critical in detecting an object. The eye requires 1 or 2 seconds to refocus. Consequently, the scanning technique must involve focusing a number of times in sequence in order to detect objects. Continuous scanning without focusing results in blurred vision.

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16 The taxi lights indicate that the aircraft is stationary or taxiing.

The block method is the visual scanning method recommended in the industry, which involves dividing the field of vision into several sections. Scanning each block separately allows the eye to focus so that it can detect details in the centre and objects in motion on the periphery. Scanning can be conducted from left to right, from right to left, or from the centre. Visual scanning can be performed in flight or on the ground.

In this case, the captain of SKV7516, seated on the left, began scanning by looking at the sky, and then looked toward the extremity of Runway 28. The first officer, seated on the right, began scanning from the intersection of Runway 28 and Taxiway Echo, and then along the runway to the right toward the extremity of Runway 28, finally looking at the sky. At the beginning of these visual scans, PRO104 was moving on the threshold of Runway 28.

Sky Regional Operating Procedures

Normal operating procedures used by Sky Regional flight crews include the flight manual and the company's aircraft SOPs, which aim to standardize how flight crews perform their tasks. Sky Regional has developed the following SOPs in order to ensure good communications with ATC and to avoid errors:

- Both crew members should listen to ATC clearances. The pilot monitoring (PM) will read back the clearance, and the pilot flying (PF) will confirm his/her understanding of the clearance to the PM.
- Pilot(s) will monitor the appropriate tower frequency when anticipating a clearance to cross or taxi onto an active runway.
- When approaching an entrance to an active runway, pilot(s) will ensure compliance with hold-short or crossing clearance by discontinuing non-monitoring tasks (e.g., flight management system [FMS] programming, airborne communications addressing and reporting system [ACARS], company radio calls, etc.).
- Before crossing or taxiing onto any runway, verbally confirm ATC clearance with other crew member(s) (if multi-crew), and visually scan the runway and approach area.

Test

The TSB investigators went to Taxiway Echo at the location where SKV7516 was positioned when PRO104 entered Runway 28. This was done at the same time of day as the occurrence. A camera was placed at a height equivalent to the eye-to-wheel height of the DHC-8. The following observations were made:

- Although visibility problems have never been reported, the structures indicating the positions of the de-icing bays can momentarily hamper the vision of pilots taxiing south on Echo and obstruct the threshold of Runway 28. However, proper visual scanning makes it possible to see the runway

Figure 4. Reflection of solar rays

threshold between these structures when the aircraft is moving.
- The King Air and its landing light were clearly visible from the runway hold line.
- The sun's rays were reflected in the windows of a building standing in the background of the runway threshold (**Erreur ! Source du renvoi introuvable.**Figure 4).

Preservation of Cockpit Voice Recorder Data

SKV7516 was fitted with a cockpit voice recorder (CVR) and a digital flight data recorder (DFDR). The flight recorders were not secured following the occurrence. However, since the DFDR recording duration is 24 hours long, flight data relating to the occurrence were recovered by the TSB. On the other hand, data relevant to the occurrence from the CVR, which has a limited recording time of 30 minutes, were lost when the aircraft continued to operate. No measures were taken to immediately protect the CVR data.
Section 6 of the *Transportation Safety Board Regulations* [17] requires the owner, operator, pilot-in-command, any crew member of the aircraft and, where the incident involves a loss of separation or a risk of collision, any ATC having direct knowledge of the incident, to report details of the incident to the Board as soon as possible and by the quickest available means. The SKV7516 crew, the PRO104 crew, and NAV CANADA did not report the occurrence within a time frame that would have allowed the TSB to request that the recorders be secured before the next flight. The TSB learned of the occurrence the following day, after reviewing an email received in the evening on the day of the occurrence through the NAV CANADA Aviation Occurrence Reporting (AOR) system (reference AOR 137097 V1).

In addition, Section 9 of the *Transportation Safety Board Regulations* requires the owner, the operator, and every crew member to preserve and protect to the extent possible any evidence relevant to a reportable occurrence. At no time did the SKV7516 flight crew notice the King Air on Runway 28. Since the SKV7516 flight crew was unaware of the risk of collision, they did not report it to the company in the minutes following the occurrence. Although the ground controller communicated with SKV7516 after the occurrence, the crew was not informed of the manoeuvre performed by PRO104 to avoid the collision. The SKV7516 flight crew only realized the severity of the occurrence several days later.

Sky Regional's operating manual (Chapter 5, page 19) clearly sets out the procedures to follow in order to preserve recordings following an incident or accident.

Runway Incursion Severity

Runway incursions are categorized according to the severity of the risk. Based on the criteria established by the International Civil Aviation Organization (ICAO), TC, and NAV CANADA, this occurrence is classed as extremely serious. The occurrence would have led to a collision if the flight crew of PRO104 had not rejected take-off and deviated from its course. According to NAV CANADA criteria, the occurrence is a Category A occurrence, which refers to situations of

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17 Transportation Safety Board Regulations (SOR/92-446), Canadian Transportation Accident Investigation And Safety Board Act (Minister of Justice: current to 02 November 2013), available at http://laws-lois.justice.gc.ca/eng/regulations/SOR-92-446/ (last accessed on 13 November 2013)

extreme risk that require immediate action to avoid a collision. Very few runway incursions fall into Category A.

According to NAV CANADA's December 2013 *Quarterly Runway Safety Report*, [18] the majority of runway incursions that occurred in Canada between 1 April 2010 and 31 March 2013 were the result of deviations committed by a pilot.

Runway Incursion Prevention Initiatives

A number of initiatives, as listed in the following timeline, have been taken by government and industry:

2000 – The Transport Canada/NAV CANADA Sub-committee on Runway Incursions (SCRI) releases 20 recommendations in its final report (document TP13795). [19]

- 2001 – The Incursion Prevention Action Team (IPAT) is assembled as a result of the SCRI report. The team is comprised of representatives from NAV CANADA and Transport Canada.
- 2005 – The runway incursion prevention action team is disbanded.
- 2006 − NAV CANADA creates the Runway Safety and Incursion Prevention Panel (RSIPP), made up of a multidisciplinary team from industry and government.
- 2007 – The ICAO *Manual on the Prevention of Runway Incursions* (document 9870) [20] is published.
- 2008 – The International Air Transport Association (IATA) releases its *Safety Trend Evaluation, Analysis and Data Exchange System: Runway Incursions* report. [21]
- 2008 – The Air Traffic Services − Pilot Communications Working Group is set up by NAV CANADA to raise awareness of the importance of employing best practices in controller-pilot communications.
- 2010 − TSB includes runway incursions on its Watchlist.

The following is a partial list of safety actions that have been taken nationally as a result of the above initiatives:

- Adoption by TC and NAV CANADA of a common definition of an incursion and a severity ranking for occurrence analysis
- Requirement for permission from ATS to cross all runways

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18 NAV CANADA, *Quarterly Runway Safety Report* (January–March 2013), page 4/11, available at http://www.navcanada.ca/EN/media/Publications/Quarterly-Runway-Safety-Report-EN.pdf (last accessed on 13 November 2013)

19 TC, National Civil Aviation Safety Committee (NCASC) Sub-committee on Runway Incursions (SCRI), *Final Report* (TP 13795E, September 2000), available at http://www.tc.gc.ca/eng /civilaviation/publications/tp13795-menu-1947.htm (last accessed on 14 November 2013)

20 International Civil Aviation Organization [ICAO] Document 9870, *Manual on the Prevention of Runway Incursions* (2007), Glossary, available at http://cfapp.icao.int/fsix/_Library/Runway%20 Incursion%20Manual-final_full_fsix.pdf (last accessed on 13 November 2013)

21 International Air Transport Association (IATA), *Safety Trend Evaluation, Analysis and Data Exchange System: Runway Incursions* (2008), report extract available at http://www.iata.org/html _email/PAX1001496/runwayincursions.pdf (last accessed on 14 November 2013)

- Implementation of standardized "line up and wait" phraseology to meet ICAO requirements
- Availability of airport diagrams on NAV CANADA's Website
- Publishing of several articles on runway incursions in TC's *Aviation Safety Newsletter*
- Inclusion on NAV CANADA's Website of a page on runway incursion

Transportation Safety Board Watchlist

Airport operations require aircraft and vehicles to move between aprons, taxiways, and runways. Sometimes this movement creates conflicts between aircraft, or between aircraft and vehicles, such as when an aircraft or vehicle mistakenly occupies an active take-off or landing area.

Through its investigations, the TSB has identified the safety issues that pose the greatest risks to Canadians. The risk of collisions on runways was placed on the inaugural Watchlist, released in March 2010. Since the TSB first placed this issue on its Watchlist, the number of these occurrences has not decreased: in 2010 there were 351, followed by another 446 in 2011. For that reason, the TSB continues to investigate these occurrences and has kept risk of runway collisions on its Watchlist, which was updated in June 2012.

From 2001 to 2009, there were 4140 of these conflicts nationwide. [22] Not all 4140 occurrences involved a risk of high-speed collision. However, in those that did, the outcomes could have been catastrophic.

The TSB has made findings and reported publicly on the risk of collisions on runways. [23] The Board remains concerned that runway incursions and risk of collisions will persist until better defences are put in place. The Board considers that improved procedures and the adoption of enhanced collision warning systems are required at Canada's airports.

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22 TC, Civil Aviation Daily Occurrence Reporting System (CADORS), available at http://wwwapps.tc.gc.ca/saf-sec-sur/2/cadors-screaq/m.aspx?lang=eng

23 TSB investigation reports A99W0036, A00P0206, A00Q0114, A00W0062, A01O0299, A07O0305, A08H0002, A09W0026, A09W0037, and A10W0040; Safety Information Letters A03C0099 and A04P0397; and Aviation Safety Advisory A09W0026-D1-A1

Analysis

The runway incursion occurred in daylight and during good visibility. Although the first officer of SKV7516 correctly read back the instruction to hold short of Runway 28, the aircraft crossed the runway without permission when PRO104 was taking off. A collision was narrowly avoided because of the PRO104 first officer's decision to perform a rejected take-off (RTO) despite the high speed of the aircraft and the action to veer to pass behind the DHC-8. SKV7516 crossed the runway because the flight crew did not remember that they must stop at the hold line, and because they had not observed PRO104 on the runway. The investigation detected no deficiency in either the air traffic control (ATC) system or the airport facilities at Montréal/Pierre Elliott Trudeau International Airport. The occurrence was the result of a combination of operational factors that interacted in such a way that safety margins were not maintained.

Air Traffic Control

To detect unforeseen threats to air safety, controllers must, among other tasks, monitor the movements of aircraft and vehicles on the ground at the airport. Since they cannot monitor all aircraft and vehicles at the same time, controllers must set priorities. In this case, the ground controller did not continuously monitor SKV7516 as it approached the hold line. Since the aircraft was operated by a scheduled airline, [24] and since the crew had correctly read back the instruction to hold short of Runway 28, the ground controller could reasonably assume that SKV7516 did not represent a danger requiring continuous monitoring. In these circumstances, because the airport does not have a RIMCAS, the controllers detected the runway incursion only as the aircraft entered the runway.

The ground controller's instruction to SKV7516 complied with communications procedures set out in the NAV CANADA *Air Traffic Control Manual of Operations* (ATC MANOPS). The instruction contained all of the elements that the controller should have provided—namely, the aircraft call sign, pertinent traffic, the route to follow, and the end of that route. SKV7516 was to give way to ACA187, and then taxi on Taxiway Echo and hold short of Runway 28. The content of the instruction was simple and easy to remember. [25]

Given that the 2 aircraft were on convergent trajectories, the controller could have provided SKV7516 with information on PRO104. However, PRO104 represented unlikely traffic for SKV7516 because of the distance separating the aircraft. The ground controller considered that PRO104 did not constitute traffic for SKV7516, because the flight crew had correctly read back the instruction to hold short of Runway 28. This assumption was mainly based [26] on the expectation that the flight crew would execute the instruction that it had read back. And yet, the great majority of runway incursions in Canada occur as the result of deviations by a pilot. In this case, because of the layout of the intersection of Taxiway Echo and Runway 28, [27] a runway

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24 Airline operators governed by CARs 705

25 The controller's message contained 3 elements, while studies of memory suggest that short-term memory is capable of recording 7 basic pieces of information.

26 The Echo/Runway 28 hold line is not equipped with a stop bar, and the airport is not equipped with a RIMCAS (runway incursion monitoring and collision avoidance system).

27 Taxiway Echo crosses Runway 10/28 at about its midpoint.

incursion at that intersection could lead to catastrophic consequences if it occurred during the take-off run of an aircraft.

In view of the foregoing, it seems reasonable to assume that, if a flight crew is given the reason for a restriction to hold short, their situational awareness [28] would be heightened, and the risk of not recalling the instruction would be reduced. An accurate mental picture of traffic on the ground can also help pilots detect either a controller or operator error.

Actions of the SKV7516 Flight Crew

The flight crew received the ground controller's instruction to hold short of Runway 28, because the first officer correctly read the instruction back, and the captain, who was at the controls, allowed ACA187 to pass and then continued to taxi. However, neither of the pilots remembered the instruction to hold short of Runway 28, nor did either confirm the controller's instruction with each other, as required by standard operating procedures (SOPs). The proximity of ACA187 caused the flight crew to prioritize the tasks of stopping the aircraft in the face of oncoming traffic and then start the aircraft moving again. After allowing the Embraer to pass, the first officer performed the normal after-landing checks while the captain manoeuvred the aircraft.

The flight crew's focus on the immediate task to give way to ACA187 likely compromised its ability to recall the instruction provided by the ground controller and the company SOPs requiring the crew to repeat the hold-short instruction to each other.

The sequence of standard actions and calls while taxiing was disrupted by an intervening event. The pilots incorrectly believed that they were permitted to cross Runway 28, even though nothing supported this belief. The ingrained habit of crossing the runway without waiting influenced the 2 pilots' perception that they could proceed without stopping.

This perception was reinforced when the captain indicated that Runway 28 and its centreline were clear. Normally, flight crews visually scan a runway immediately before arriving at the hold line. In this case, the flight crew had performed its visual scan well before, [29] possibly because they did not plan to stop. The captain had not seen PRO104, which was on the runway threshold with its landing light on. The following factors may have contributed to the failure to notice PRO104:

- The relatively small dimensions of a Beech A100 King Air
- Background reflection of the sun's rays
- The de-icing bay sign structures

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[28] Situational awareness refers to perception of the elements in the operating environment at a specific time and place, an understanding of their significance, a projection of their status in the immediate future, and prediction of how various actions will influence attainment of the various parties' goals.

[29] Visual scanning was performed 650 feet from the hold line.

- Inattentional blindness [30] (i.e., the captain was not expecting to see an aircraft)

Listening to the correct frequency is key to preventing runway incursions. In this regard, Sky Regional's SOPs stipulate that flight crews must listen to the tower frequency whenever they cross or taxi on an active runway. SKV7516 was tuned to the apron frequency [31] when it was on the runway, and there had been no radio communication between the tower and PRO104 after the flight crew had received clearance to take off almost 2 minutes earlier. Therefore, in this case, listening to the airport frequency would not have had any impact on the sequence of events.

SOPs are designed, in part, to reduce memory and attention errors through the use of well-defined procedures. The company SOPs regarding communication do not take into account the particular layout of every airport. The SOPs required the crew to switch to the apron frequency after the aircraft's tail had crossed the south hold line. Given the proximity of the apron to the runway at Montréal/Pierre Elliott Trudeau International Airport, the crew would have had little time to communicate with AMS and be forced to stop the aircraft due to lack of traffic instructions.

The flight crew probably deviated from SOPs because doing so seemed more practical in this situation. Their haste in communicating with the apron management service (AMS) reflects a desire to avoid stopping the aircraft enroute to their gate.

Stopping an Aircraft on a Controller's Instructions

Existing markings and signage at the hold line did not allow the SKV7516 flight crew to realize their mistake and did not alert them to the fact that an aircraft was taking off from Runway 28. As a result, only direct intervention by the controllers could have prevented the runway incursion.

The 2 controllers attempted to communicate with SKV7516 as it entered the runway and as PRO104 was approaching rotation speed. The ground controller transmitted an order to stop to the SKV7516 flight crew, but because the crew had left the ground frequency and tuned to the apron frequency, SKV7516 did not hear the ground controller.

One might assume that a controller must intervene with flight crews whenever realizing that a collision is about to occur. However, such an intervention in a dynamic environment carries risks, because numerous variables are involved. Both intervention and lack thereof can reduce or increase the risks of a collision. In the case of an instruction to stop taxiing or take-off, the controller does not know the aircraft's ability to stop. The controller cannot know whether the

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30 The phenomenon of inattentional blindness is characterized by failure to notice a stimulus that is ordinarily plainly visible (A. Mack and I. Rock, *Inattentional blindness* [Cambridge, MA: MIT Press, 1998]).

31 The flight crew had not heard the ground controllers' and airport controllers' calls when the aircraft entered the runway, and had communicated with the apron management service (AMS) while the aircraft was on Runway 28.

taxiing aircraft will stop before or on the runway, nor does the controller know whether the aircraft taking off could stop before the collision or whether the aircraft has exceeded V_1. [32]

In light of these risks, the effectiveness of a control intervention depends on the location of the aircraft involved. Consequently, it is vital that flight crews are able to react in time to control instructions. It is not certain that a RIMCAS (runway incursion monitoring and collision avoidance system) could have prevented the runway incursion, even if Montréal/Pierre Elliott Trudeau International Airport had been equipped with one. Moreover, RIMCAS is merely an alert system and does not determine whether stopping ground traffic or interrupting take-off is the best strategy to prevent a collision. This system will continue to rely on the interpretation of warnings by controllers and their subsequent radio communication with aircraft and vehicles.

This report again highlights the pressing need for solutions to address the problem of runway incursions, such as implementation of a system for transmitting warnings directly to flight crews and installation of runway status lights (RWSL). In the absence of additional strategies to guard against runway incursions, the risk of collision on runways will continue.

Use of Both English and French

ATC communications with SKV7516 were in English and with PRO104 were in French. The investigation examined the use of both English and French. In this case, the use of both languages, as permitted, had no effect on the occurrence. The investigation was unable to confirm the radio frequency to which SKV7516 was tuned when the airport controller cleared PRO104 to take off from Runway 28. However, since PRO104 was cleared to take off 21 seconds after SKV7516 had been instructed to contact the ground controller, it is probable that the 2 aircraft were no longer on the same frequency.

Decision by the PRO104 Flight Crew to Continue the Flight

After the RTO, the PRO104 pilots did not consider that any damage was caused during the manoeuvre. But inspection of the aircraft after the flight revealed significant damage to the outer left tire and a leak of brake fluid on the same side. Based on the post-occurrence analysis, it would have been prudent to inspect the landing gear and related systems before continuing the flight. But in the absence of established guidance or procedures, their decision to continue the flight following the RTO was based on their perception of the condition of the aircraft. Contributing to this perception was an absence of alarm system indicators, abnormal noises, tactile clues, and external observations. Given this factor, and considering the PPC had been postponed several times, the flight crew's desire to complete the flight may have influenced their decision to take off, and this was consistent with established standards and policies.

In the event of a high-speed RTO, the flight crew must consider possible consequences. Among other possibilities, there is a risk of brakes overheating and damage to landing gear components. Given that an aircraft's mass and speed have a direct effect on the energy required to slow it, intense braking during a RTO at high speed may have major repercussions for its

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[32] V_1 refers to the maximum take-off speed at which the pilot can safely stop the aircraft on the remainder of the runway. It is also the minimum speed at which the pilot can continue take-off safely and accelerate to reach safe take-off speed (V_2), even if a critical engine failure should occur.

safety. Moreover, despite the low mass of PRO104, the RTO caused damage to some components of the left-side landing gear, although no operational consequences ensued. In conclusion, an overly optimistic assessment of the aircraft's condition led the PRO104 flight crew to take off with a damaged tire and fluid leakage of which the crew were unaware.

Findings

Findings as to Causes and Contributing Factors

1. While the ground controller was instructing SKV7516 to hold short of Runway 28, the pilots' attention was focused on an aircraft taxiing in the opposite direction. As a result, the SKV7516 pilots did not confirm between themselves the ground controller's instruction to hold short of Runway 28, and resumed taxiing.

2. The SKV7516 flight crew members incorrectly believed that they were permitted to cross Runway 28 notwithstanding the first officer's accurate readback of the instruction to hold short of Runway 28. As a result, SKV7516 did not stop at the hold line and entered the runway.

3. The visual scan conducted by the SKV7516 captain was ineffective and did not identify that PRO104 was on Runway 28.

4. SKV7516 crossed Runway 28 without permission in front of PRO104, which was approaching its take-off rotation speed. Consequently, the runway incursion resulted in an extremely serious risk of collision.

Findings as to Risk

1. If an aircraft inspection is not conducted following a high-speed rejected take-off, there is a risk that a flight crew may take off with a damaged aircraft.

2. If a flight crew is tuned to an incorrect frequency as that crew's aircraft crosses a runway, there is an increased risk that the ground controllers and airport controllers will not be able to contact the flight crew.

3. In the absence of additional strategies to safeguard against runway incursions, the risk of collisions on runways will persist.

Other Findings

1. The PRO104 first officer reacted quickly to the runway incursion because of previous simulator training.

2. PRO104 rejected its take-off at high speed and had to veer away from its trajectory to avoid colliding with SKV7516.

Safety Action

Safety Action Taken

Sky Regional Airline Inc.

Further to the occurrence, Sky Regional issued a safety bulletin to all of its pilots by email. The safety bulletin reminded company pilots of the importance of complying with aircraft standard operating procedures (SOPs) on the setting of radio frequencies before entering a runway. In addition, the safety bulletin reiterated the requirement to confirm air traffic control (ATC) authorizations between themselves.

Sky Regional has modified its checklist to reduce distraction during taxi operations.

Lastly, Sky Regional ensures that, during flight training, pilots apply the SOPs regarding ATC communications in order to prevent runway incursions.

Aéroports de Montréal

Aéroports de Montréal (ADM) has improved signage by painting red squares on Taxiway Echo on either side of Runway 10/28. In addition, ADM has set up a local runway safety committee, established in the spring of 2013, in order to follow the International Civil Aviation Organization (ICAO) recommendations for the prevention of runway incursions.

NAV CANADA

NAV CANADA has implemented several procedures, specified in its *Air Traffic Control Manual of Operations* (ATC MANOPS), to reduce the use of Runway 10/28 in order to reduce runway incursions.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 02 October 2013. It was officially released on 09 January 2014.

Visit the Transportation Safety Board's website (*www.bst-tsb.gc.ca*) for information about the Transportation Safety Board and its products and services. You will also find the Watchlist, which identifies the transportation safety issues that pose the greatest risk to Canadians. In each case, the TSB has found that actions taken to date are inadequate, and that industry and regulators need to take additional concrete measures to eliminate the risks.