Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

AVIATION INVESTIGATION REPORT

A04P0047

RISK OF COLLISION ON THE RUNWAY

NAV CANADA
VANCOUVER TOWER
VANCOUVER INTERNATIONAL AIRPORT,
BRITISH COLUMBIA
03 MARCH 2004

Canada

Aviation Investigation Report

Risk of Collision on the Runway

NAV CANADA
Vancouver Tower
Vancouver International Airport, British Columbia
03 March 2004

Report Number A04P0047

Summary

A privately owned Cessna 182 (C-FTGQ, registration 18253153) was on a day visual flight rules flight from Victoria, British Columbia, to Vancouver International Airport, British Columbia. The aircraft's skin was unpainted aluminum. When the Cessna was about five nautical miles from the airport, the Vancouver Tower south (TS) controller cleared the pilot to proceed directly to the threshold of Runway 08 right (08R), the active runway. At the same time, a WestJet Airlines Boeing 737 (WJA168) was taxiing to Runway 08R for departure to Calgary, Alberta.

Just after the Cessna crossed the threshold, the TS controller cleared WJA168, then holding at the threshold, to take position on Runway 08R. When the TS controller saw that the Cessna had touched down, he instructed the pilot to exit the runway to the right at Runway 12, which was 4500 feet from the threshold of Runway 08R, and to contact Vancouver ground control. The pilot correctly read back this instruction. Seconds later, when the TS controller assessed that the Cessna was turning off onto Runway 12, he cleared WJA168 for take-off. However, the Cessna pilot had passed the exit to Runway 12 and remained on Runway 08R. At about 1437 Pacific standard time, with WJA168 now on its take-off roll, the TS controller was advised that the Cessna was still on the active runway. He immediately instructed the Cessna pilot to vacate the runway quickly at the next taxiway and to stay to the right-hand side of the runway. WJA168 passed abeam of the Cessna, about 200 feet above and 100 feet to the left, while the Cessna was still on the runway at the entrance to Taxiway A2.

Ce rapport est également disponible en français.

Other Factual Information

The following control positions in the tower were staffed: Vancouver tower south (TS), ground south (GS), tower advisory (TA), and combined tower/ground north positions. At the time of the incident, the traffic level for the TS controller was light to moderate and included a few arrivals interspersed with a steady stream of departures. The TS controller was responsible for arrivals and departures on runways 08R and 12.

The weather at 1420 Pacific standard time[1] was reported as follows: wind 130° True at 5 knots, visibility 10 statute miles, light rain showers, a few clouds at 1200 feet, ceiling 1900 feet broken, 5000 feet overcast, altimeter setting 29.96, remarks: ceiling ragged. The weather at 1439 was as follows: wind 140° True at 6 knots, visibility 8 miles, ceiling 1600 feet broken, 2500 feet overcast, altimeter setting 29.96. There was no indication that the runway was wet at the time of the incident, although it was reported that there were puddles of water in the infield grass.

When over Active Pass at 1300 feet above mean sea level (asl), approximately 20 nautical miles (nm) south of Vancouver International Airport, the Cessna pilot contacted the TA controller at 1424:41. The TA controller cleared the Cessna for a Sandheads visual flight rules arrival procedure for Runway 08R and issued the current altimeter setting. At 1432:45, the TA controller instructed the Cessna pilot to follow a Shorts SD-360 aircraft that was two miles ahead and to contact the Vancouver tower south (TS) controller. The pilot advised that the traffic was in sight.

The Cessna pilot contacted the TS controller at 1432:57 and was advised that he was number two on approach behind the Shorts SD-360, which was then three miles ahead. The TS controller had just requested that the Shorts SD-360 fly directly to the threshold of Runway 08R and keep the speed up. The TS controller asked the Cessna to keep the base leg for Runway 08R square to keep the traffic pattern close to the airport to reduce the possibility of delays to departing traffic. At the time, there were three aircraft waiting for departure. Twenty seconds later, the controller again requested that the Cessna keep the base leg square, and advised that jet traffic would be departing ahead and that the Cessna was now number one in the landing sequence. At 1435:14, the TS controller instructed C-FTGQ to fly directly to the threshold of Runway 08R.

At 1435:53, the TS controller cleared the Cessna to land on Runway 08R. The Cessna crossed the threshold at a ground speed of 85 to 90 knots, approximately 30 knots faster than usual for this aircraft.[2] Once the Cessna had passed the threshold of Runway 08R, the TS controller cleared WJA168, which was the next aircraft in line for departure, to take position on Runway 08R. At 1437:37, the TS controller instructed the Cessna to exit Runway 08R onto Runway 12 and to contact the ground controller on frequency 121.7 MHz. The pilot acknowledged the instruction.

The TS controller had earlier issued similar exit instructions to a Beech 1900 landing on Runway 08R, and that aircraft had exited onto Runway 12 without difficulty. When the

---

1 All times are Pacific standard time (Coordinated Universal Time minus eight hours).

2 C-FTGQ is a modified Cessna 182 incorporating multiple STOL high-lift wing devices, allowing significantly lower-than-normal landing speeds.

TS controller issued exit instructions to the Cessna, he believed that the aircraft had already touched down; however, it was still airborne in the landing flare. The pilot had flown down the runway for a considerable distance to lose the extra speed, and the aircraft did not touch down until it was a few hundred feet short of the intersection with Runway 12.

As soon as the Cessna touched down, the pilot applied the wheel brakes; however, the aircraft was light on its wheels and started to skid to the right. The pilot immediately released the brakes and applied power to maintain directional control. The aircraft was travelling too fast to turn onto Runway 12 or onto the next available taxiway, E/H. The pilot, who was relatively unfamiliar with Vancouver International Airport, was now unsure of his position with respect to Runway 12, but was hesitant to ask for further taxi directions. The pilot did not advise the TS controller that he had not turned off the runway as instructed (see Appendix A) nor did he ask for further taxi directions. The pilot assumed that it would be quite apparent to the controller that he had not turned onto Runway 12.

After having issued exit instructions to the Cessna, the TS controller, in accordance with established procedures, handed the flight data strip for the aircraft to the GS controller. He then looked up and observed what he thought was the Cessna commencing a turn to exit Runway 08R onto Runway 12. The TS controller then issued the take-off clearance to WJA168. He did not confirm that the Cessna was off the runway, nor did he see the Cessna on the runway during a subsequent scan of Runway 08R. The Cessna pilot did not hear the TS controller issue the take-off clearance to WJA168 even if he was monitoring the same frequency.

WJA168 was on Taxiway L at the threshold of Runway 08R when the Cessna crossed the landing threshold. On receiving clearance to taxi into position, the crew of WJA168 scanned the runway approach and departure paths and taxied onto the runway. While WJA168 was lining up with the runway centreline, it was cleared for take-off. The pilot flying again scanned the runway, and the pilot not flying completed the remaining items on the pre-take-off checklist. Neither pilot noted that the Cessna was still on the runway.

After WJA168 had passed 80 knots on the take-off run, the pilot flying saw a light ahead near the side of the runway. He alerted the pilot not flying, and both pilots looked for the source of the light. On hearing the TS controller instruct an aircraft to expeditiously vacate the runway, the pilot flying saw the Cessna. Assessing the situation, he determined that there was sufficient room to continue the take-off and avoid the other aircraft, rather than abort the take-off at high speed thus risking a collision on the runway. WJA168 rotated at approximately 145 knots just beyond the intersection of Runway 12. A replay of the airport surface detection equipment (ASDE) radar showed that WJA168 passed approximately 100 feet to the left of the Cessna at an estimated height of approximately 200 feet. At the time, the Cessna was still on the runway at the entrance to Taxiway A2.

The GS controller, who was expecting the Cessna to contact him once clear of the runway, spotted the Cessna still on the runway while WJA168 was in the take-off roll. He immediately alerted the TS controller and then, on the south ground frequency, instructed the Cessna to get off the runway, adding that a jet was taking off from behind. The Cessna pilot did not receive these instructions because he was still monitoring the south tower frequency.

When informed that the Cessna was still on the runway, the TS controller made a visual assessment of the situation, including the speeds and positions of both aircraft, and decided not to instruct WJA168 to abort the take-off. He then instructed the Cessna to immediately get off the runway at the next exit, repeating the word *expedite* several times.

After the TS controller cleared WJA168 for take-off, he entered a departure time on the paper flight data strip and then moved the electronic flight data strip on the extended computer display system (EXCDS)[3] to the departure section of the screen. The flight data strip for WJA168 then appeared on the departure controller's screen, negating the requirement for verbal communication with the departure controller to indicate that WJA168 had departed. The TS controller then cleared the next aircraft in line to take position on Runway 08R, which required him to slide the paper strip for that aircraft part way out of the holder to indicate that the aircraft was on the runway. These activities required the TS controller to focus his attention inside the tower and reduced the time available for him to look out onto the airfield.

Human vision is subject to numerous inherent limitations that affect the ability of an individual to discern and visually acquire an object. A number of studies have been conducted to determine how pilots search and scan for conflicting aircraft in the air and to explore why aircraft are frequently not detected visually. Some of the results of these studies are applicable to air traffic controllers scanning a runway or taxiway to determine if there are any obstructions that could affect the safety of aircraft manoeuvring on the ground. For example, it has been shown that, when an individual scans rapidly across an area, the movement of the eyes is not smooth, rather the eyes

> … shift in a series of jerky movements or jumps called saccades.… A study conducted at the U.S. Naval Aerospace Medical Laboratory showed that when the eyes are in saccadic movement, visual acuity decreases sharply, leaving gaps in the distant field of vision.[4]

This physiological characteristic greatly reduces the efficiency of visual scanning, often preventing objects from being detected.

The NAV CANADA *Air Traffic Control Manual of Operations* (ATC MANOPS), Part 3, Section 308, Visual Scanning — Manoeuvring Area, states that controllers have a responsibility

> … to visually scan the manoeuvring area thoroughly before issuing clearances or instructions to airport traffic, and, to the extent possible, at other frequent intervals, and to ensure that the runway to be used by a departing or arriving aircraft is free, or will be free, of all known obstacles including vehicles, equipment and personnel before the departing aircraft commences its take-off roll.

---

[3] The extended computer display system, or EXCDS, is an electronic flight progress strip marking and coordination system designed by NAV CANADA.

[4] S.S. Krause, "Collision Avoidance Must Go Beyond 'See and Avoid' to 'Search and Detect'," *Flight Safety Digest*, 16:5 (May 1997): 5.

In addition, a number of scanning techniques and helps are listed in the note to section 308.1 of the same publication as follows:

- scanning has to be systematic;
- people can get "object hypnosis" and only see things that move (scanning at least twice will help overcome this);
- the eyes should move from one point to another (not in one continuous sweep);
- scanning should be from left to right, the same as you read; and
- the eye can only focus on an area that would be covered by the fist when your arm is extended in front of you.

Recent refresher training for controllers has not included effective visual scanning of manoeuvring surfaces to ensure that there are no hazards or potential conflicts present, nor has it included information on the limits to human vision.

ATC MANOPS, Part 3, Section 352, Arrivals and Departures, prescribes in part that a controller must ensure that a departing aircraft "does not begin take-off roll until … the preceding aircraft has landed and taxied off the runway, or there is every assurance that it will vacate the runway by the time the departure starts the take-off roll."

The *Aeronautical Information Publication* (AIP),[5] Rules of the Air (RAC), section 4.4.4, indicates that "an aircraft is not considered clear of the runway until all parts of the aircraft are past the taxi holding position line or the 200-foot point."

Canadian Aviation Regulations (CARs), Section 602.31, specify that a pilot shall "comply with and acknowledge, to the appropriate air traffic control unit, all of the air traffic control instructions directed to and received by the pilot-in-command." However, there is no provision that requires a pilot to advise air traffic control immediately when it is not possible to comply with the instruction.

The format that air traffic controllers use to issue runway exit instructions is specified in ATC MANOPS, Section 345, and includes identification of the aircraft and unit, and specific instructions about the exit and the point at which to contact ground control. A note in the same section states that "Unless otherwise instructed by the tower, a landing aircraft will continue to taxi in the landing direction, proceed to the nearest suitable taxiway and exit the runway without delay." There is similar information included in the AIP, section RAC 4.4.4. With the exception of exiting a runway onto another runway, pilots should exit on the nearest suitable taxiway and not delay getting off the runway. Specifying a particular exit is at the discretion of the controller; however, the pilot is normally in the best position to determine which exit is most suitable, depending on aircraft speed and runway surface conditions.

---

[5] The AIP is intended to serve as the aviation community's source document for pre-flight reference information essential to aircraft operation in Canada's national airspace system.

The ASDE radar at Vancouver International Airport was operating at the time of the incident. This high-definition radar system incorporates a runway incursion monitoring and conflict alert sub-system (RIMCAS) software program. When activated, it provides an alert comprising both an audible and a visual presentation if the system detects a potentially hazardous situation. For example, if a departing aircraft is accelerating for take-off while there is another aircraft, vehicle, or other tracked object on the runway, it generates an alert. At the time of the incident, the RIMCAS program had not yet been activated because of a continuing problem with false targets that caused the ASDE to generate false conflict alerts.

Analysis

Neither the pilots of the two aircraft involved nor the TS controller had sufficient situational awareness to avoid the development of a serious risk of collision. The TS controller relied on a single observation of the Cessna, which was apparently commencing a turn onto Runway 12, to conclude that Runway 08R was clear. He then continued with the next phase of his traffic plan. The pilot of the Cessna, once past the Runway 12 intersection, but unsure of his position, did not inform the TS controller and continued along Runway 08R. He did not hear the take-off clearance given to WJA168, although he was monitoring the same frequency. The pilot flying WJA168 did not see the Cessna on the runway, despite conducting a visual scan of the runway before commencing the take-off. Having received a take-off clearance, the pilot expected that the runway would be free of obstructions.

Scanning for obstructions or traffic is an essential yet routine air traffic control function since it occurs continually during a controller's shift. The routine nature of the scanning activity, combined with limitations in human visual scanning, results in a risk that an object, such as a small aircraft, will be missed. Controllers may not receive sufficient training to make them aware of some of the limitations of human vision and to adjust their own scanning techniques to increase the probability of detecting objects on the manoeuvring area. Regardless, the limitations of visual detection repeatedly show that pilots and controllers alike need to carefully and constantly apply effective and varied searching and scanning techniques to increase the likelihood of detecting a hazard affecting the safety of flight.

The Cessna's skin was unpainted aluminum and blended with the grey background. As well, it was a small aircraft and was already almost a mile down the runway at the time WJA168 commenced take-off. Low contrast between the aircraft and its background, the aircraft's small size, and its distance from WJA168 reduced the probability of it being sighted.

The activities involved in marking and moving flight data strips—both paper and electronic—frequently require controllers to shift their attention from outside to inside the tower. These actions may result in a controller working with an outdated situational awareness model, which can lead to an occurrence. Furthermore, the action of passing the flight data strip for the Cessna to the GS controller could have reinforced the TS controller's perception or expectation that all required actions were completed and that the runway was available for the next aircraft to depart.

As a result of the long and fast touchdown, the pilot of the Cessna was unable to slow the aircraft sufficiently to vacate the runway as instructed. When he did not inform the TS controller

that he was unsure about the exit to Runway 12, and that he could not slow down sufficiently, it compounded the TS controller's delay in recognizing that his plan had broken down and that a risk of collision situation was developing. Exacerbating the situation was the Cessna pilot's hesitation to take the next available exit (E/H) after the Runway 12 intersection, and his continuation down the runway to Taxiway A2.

A controller may not always know the circumstances or limitations under which a pilot is operating when a specific exit from the runway is specified. Unless the pilot immediately indicates that the specified exit is not suitable, the controller may assume that the pilot can comply with the instructions and, as a result, will not monitor closely the aircraft's progress. The pilot may not know when receiving exit instructions whether compliance will be possible. In this incident, because the pilot of the Cessna was concentrating on landing and slowing the aircraft at the point he was to exit, he passed it by. Issuing specific exit instructions requires a high level of monitoring by the controller to ensure compliance.

The TS controller had issued identical exit instructions to a larger Beech 1900 aircraft a few minutes earlier, and the pilot of that aircraft was able to exit onto Runway 12. The TS controller reasonably anticipated that the Cessna—a smaller, lighter, and slower aircraft—would be able to comply with similar instructions to exit onto Runway 12, and he did not closely monitor the aircraft's progress.

In summary, the TS controller would have formed his mental picture of the dynamic situation from the following factors:

- a larger aircraft had just successfully exited onto Runway 12;
- he detected nothing unusual about the approach profile of the Cessna;
- the Cessna pilot immediately and correctly read back the exit instructions; and
- he perceived that the Cessna had turned at the intersection of Runway 12.

As of March 2005, the RIMCAS program on the ASDE has not been activated. The airport lacked an automated collision-avoidance defence; therefore, the last opportunity to avoid a collision was provided by two nearly simultaneous events:

- the pilot of WJA168 saw a light on the Cessna ahead and assessed that he had a serious aircraft conflict situation at a point when he had sufficient time to lift off and avoid a collision; and

- the GS controller saw the Cessna on the runway and alerted the TS controller. This allowed the TS controller to issue instructions to the Cessna to remain on the right side of the runway and to expedite travel to the next exit.

Findings as to Causes and Contributing Factors

1. The Cessna's landing was faster and further down the runway than normal, causing the pilot to miss the exit at Runway 12 and invalidating the tower south (TS) controller's air traffic management plan.

2. The TS controller perceived the Cessna to be turning off the active runway when in fact the Cessna remained on the runway. The TS controller cleared WJA168 for take-off without ensuring that the runway was clear of obstruction, resulting in a risk of collision between WJA168 and the Cessna.

3. The Cessna pilot did not advise the TS controller that he was unsure of his position on the runway or that he had missed the exit to Runway 12, thereby delaying the TS controller's recognition of the developing conflict.

4. Although the pilot of WJA168 scanned the runway ahead before commencing the take-off roll, he did not detect the Cessna on Runway 08R, resulting in a risk of collision between WJA168 and the Cessna. The Cessna's low visibility due to its lack of contrast against the background, its small size, and the distance between the two aircraft were probably contributing factors.

Findings as to Risk

1. The visual scanning techniques used by controllers and pilots to detect and avoid conflicting traffic on or near a runway are not consistently effective in detecting all aircraft or other obstructions, thereby presenting a risk of a collision. Controllers who are not aware of the physiological limitations of human vision may not adjust their scanning techniques to compensate.

2. The pilot of the Cessna acknowledged an air traffic control instruction to exit Runway 08R at Runway 12, but missed the exit and continued on Runway 08R without advising the TS controller. There is no requirement for a pilot to immediately advise the tower when unable to comply with the exit instructions.

3. The airport surface detection equipment (ASDE) radar system is equipped with a runway incursion monitoring and conflict alert sub-system (RIMCAS) software program to provide an alert to the controller of a potentially hazardous situation on the runway; this alert system was still not operational as of March 2005.

Safety Action Taken

Transport Canada has noted that guidance material contained in Aeronautical Information Publication, Section RAC 1.7, provides clear guidelines as to what pilots-in-command (PIC) are expected to do when they find an air traffic control (ATC) clearance unacceptable, but it is not clear as to what PICs are expected to do when they cannot comply with an ATC instruction. Transport Canada will therefore amend the guidance provided in Section RAC 1.7 to indicate that PICs are expected to immediately advise ATC if they are not able to comply with an ATC instruction that they have received and acknowledged.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 21 March 2005.

Appendix A – Near Miss Between WJA168 and C-FTGQ