Transportation Safety Board of Canada
Bureau de la sécurité des transports du Canada

AIR TRANSPORTATION SAFETY INVESTIGATION REPORT A23W0122

RUNWAY INCURSION AND RISK OF COLLISION

Airport Terminal Services aircraft tow vehicles ATSTOW504 +1
and
Jazz Aviation LP De Havilland Aircraft of Canada Limited DHC-8-402,
C-GGNZ
Calgary International Airport (CYYC), Alberta
06 October 2023

Canada

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Summary

Shortly before 1100 Mountain Daylight Time on 06 October 2023, 2 aircraft tow vehicles (tugs) (call sign ATSTOW504 +1) operated by Airport Terminal Services at Calgary International Airport (CYYC), Alberta, planned to drive from Apron 1, to the south side of the airport to reposition an aircraft that was parked on Runway 26. The lead tug driver was given instructions by the ground controller to proceed south on taxiways C, C1, and Y, and hold short of Runway 26. These instructions were amended shortly after with an instruction to enter Taxiway C2 to give way to an aircraft taxiing north, in the opposite direction, on Taxiway C. This communication included an instruction to hold short of Runway 17R, which the lead driver read back.

Once the taxiing aircraft had passed, the ground controller instructed the lead tug driver to continue on Taxiway C and hold short of Runway 26. The lead driver read back the instruction and, at 1104, both vehicles proceeded onto Runway 17R. At that time, another aircraft, a Jazz Aviation LP De Havilland Aircraft of Canada Limited DHC-8-402 operating as flight JZA7124, was beginning its take-off roll on Runway 17R. The aircraft's flight crew noticed the 2 tugs as the aircraft approached the decision speed (V_1), but the flight crew elected to continue the takeoff. When the aircraft became airborne, it was approximately 3700 feet laterally away from the tugs. It then passed overhead the tugs and climbed through 350 feet above ground level as they exited the runway at Taxiway U.

1.0 FACTUAL INFORMATION

1.1 History of the occurrence

On the morning of 06 October 2023, the active runways[1] at Calgary International Airport (CYYC), Alberta, were Runway 17L and Runway 17R. At 1030,[2] after the morning's peak of departing aircraft, air traffic controller positions in the Calgary control tower were reduced to the following 3:

- combined east/west tower;
- west ground; and
- combined east ground, apron advisory, and clearance delivery.

In addition, a decision was made at this time to shut down the advanced surface movement guidance and control system (A-SMGCS)[3] to allow for a planned software update. The shutdown had been estimated to last 30 minutes. This meant the controllers would not be able to use the system for monitoring ground movements or activate the virtual stop bars to help mitigate the consequence of a runway incursion. The 3 controllers had to rely solely on visually scanning the areas for which they were responsible. To mitigate this loss of surveillance equipment, the air traffic control (ATC) unit moved to a simplified movement posture called Segregated Plus.[4] By organizing the runways for separate purposes—Runway 17L for landings only and Runway 17R for takeoffs and landings, with increased spacing—the controllers had more time for the visual confirmation of movements on the airport surface. Operations at this time were considered moderate for traffic volume and medium complexity due to the A-SMGCS being shut down.

At 1059, the drivers of 2 aircraft tow vehicles (tugs), operated by Airport Terminal Services (ATS), called the ground controller to ask for instructions on how to proceed from the main apron, Apron 1, where they were, to the south end of the airport to move an aircraft parked on Runway 26, which was closed, to Apron 5. In summary, the lead tug driver was given instructions by the ground controller to proceed south on taxiways C, C1, and Y, and hold short of Runway 26.

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1 An active runway is "any runway or runways currently being used for takeoff or landing. When multiple runways are used, they are all considered active runways." (Source: NAV CANADA, *Manual of Air Traffic Services—Advisory Services—Flight Service Station* [effective 01 April 2024], ATS Glossary 1.7, p. 249.)

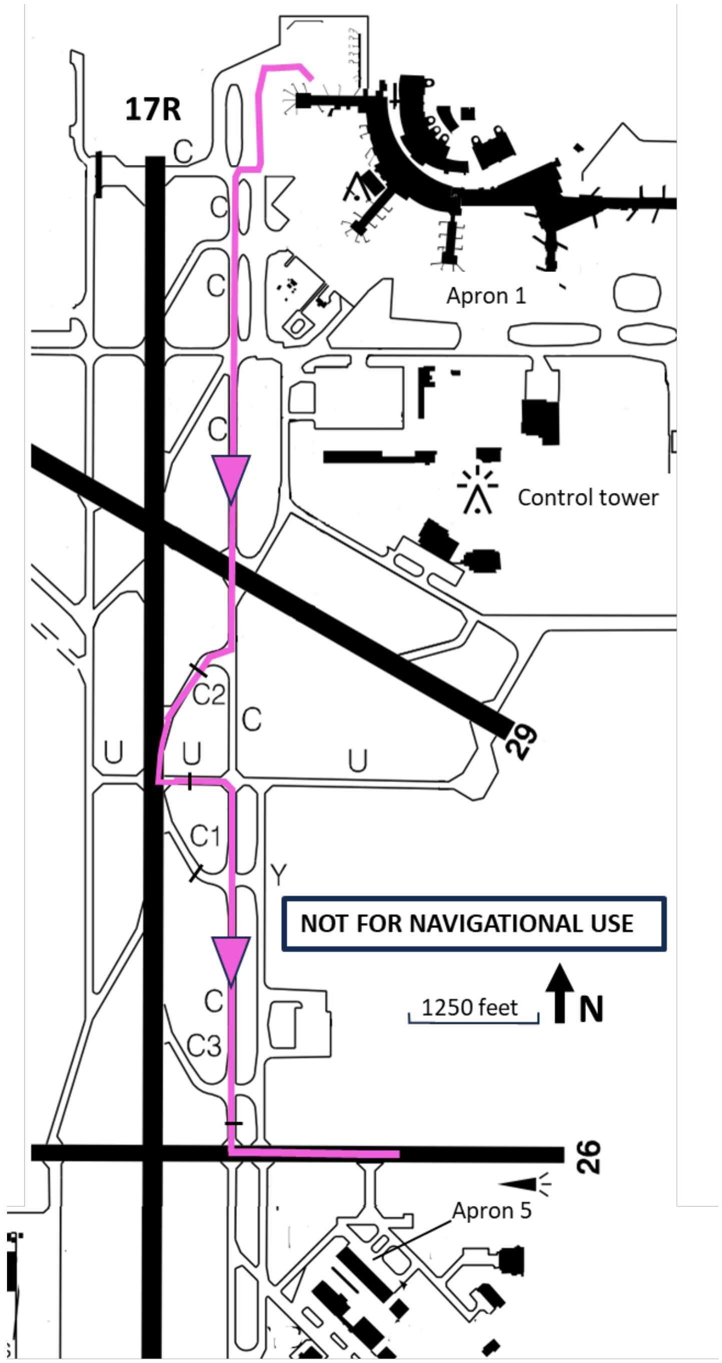
2 All times are Mountain Daylight Time (Coordinated Universal Time minus 6 hours).

3 See section 1.18.1.1 *Advanced surface movement guidance and control system* in this report for a description of the A-SMGCS.

4 Segregated Plus is a process instituted by the CYYC tower unit to mitigate the loss of surface surveillance equipment. It involves changing the airport's mode of operation to the following: landings only on Runway 17L, with a separation of 3 nautical miles (NM) between aircraft; and both takeoffs and landings on Runway 17R but with 12-NM separation to allow additional time between aircraft movements.

An aircraft that had recently landed, Jazz Aviation LP's De Havilland Aircraft of Canada Limited DHC-8-402, operating as flight JZA133, had exited Runway 17R on Taxiway C3 and was making its way north on Taxiway C. Due to line painting being conducted on Taxiway U between Taxiway C and Runway 29, Taxiway Y was inaccessible to aircraft. Therefore, at 1101:45, the ground controller instructed the 2 southbound tugs to give way to this aircraft by moving onto Taxiway C2, and to hold short of Runway 17R while remaining clear of Taxiway C (Figure 1). The driver of the lead tug asked the ground controller for clarification, which he received and then correctly read back.

Figure 1. Tugs' path (solid magenta line with directional arrows) at Calgary International Airport (Source: NAV CANADA, *Canada Air Pilot* [CAP], CAP 3: Alberta, Saskatchewan, and Manitoba, effective 11 July 2024 to 05 September 2024, with TSB annotations)



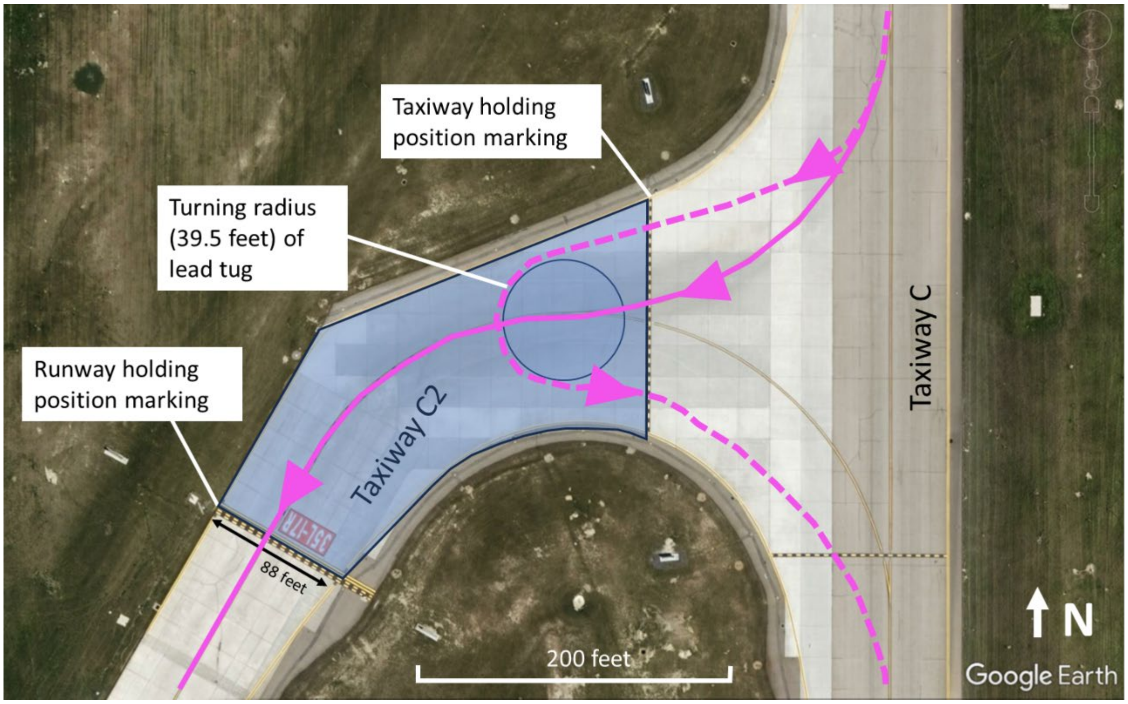
At 1102:25, a different aircraft, Jazz Aviation LP's De Havilland Aircraft of Canada Limited DHC-8-402, operating as flight JZA7124 and preparing for departure, was instructed to taxi from Apron 1 and hold short of Runway 17R. Meanwhile, around this time, the drivers of the tugs had entered Taxiway C2 to give way to flight JZA133, which was travelling north on Taxiway C.

By 1103:00, the 2 tugs were on Taxiway C2 and stopped on the centreline, just short of the runway holding position marking for Runway 17R. For the lead tug driver, this was a typical position at which to stop when told to hold short of a runway, because of the fact that when a driver is told to hold short of a runway, the next instruction from ATC is usually to continue across the runway holding position marking and onto the runway rather than to turn around. Once flight JZA133 had passed north of Taxiway C2 on Taxiway C, the tugs were instructed by the ground controller, at 1103:47, to proceed onto Taxiway C and hold short of Runway 26, which the lead aircraft tug driver read back. It was at approximately this time that the departing aircraft, which had been holding short of Runway 17R, was given the instruction by the tower controller to line up and wait on that runway, followed by a clearance to take off at 1104:00.

At this time, the lead tug was positioned close to the Runway 17R runway holding position marking on Taxiway C2. The driver of the lead vehicle had never turned around on a taxiway before and believed this was not allowed. In the absence of an explicit instruction to turn around in the ground controller's last communication, the lead driver also believed that doing so on Taxiway C2 to join Taxiway C would not be possible because he perceived that there was not enough space for both vehicles to turn around, given each vehicle's turning radius (Figure 2).

He did not deem backing up an option because it would have required both drivers to exit their vehicles; disconnect the towbar from the 2nd tug, which would have taken time; and coordinate the tugs' movements. In addition, during the summer, the lead tug driver had taken similar detours onto Runway 29 during construction work on and near Runway 29. Consequently, at 1104:04, the 2 tugs crossed the runway holding position marking and entered Runway 17R from Taxiway C2, resulting in a runway incursion. The lead tug driver had reasoned that if this was an incorrect action, the ground controller would intervene and stop him and the other driver. Shortly afterwards, at 1104:16, the flight crew of the departing aircraft began its take-off roll.

Figure 2. Path that the ground controller had intended for the 2 tugs (dashed magenta line) and the actual path taken (solid magenta line). The shaded area is where the ground controller had wanted the tugs to hold until the aircraft taxiing on Taxiway C in the opposite direction (flight JZA133) had passed (Source: Google Earth, with TSB annotations)



At 1104:25, the tugs were on the runway surface for Runway 17R, resulting in a risk of collision with the aircraft that had just begun its take-off roll. The vehicles continued to travel along the runway with the intent of exiting onto Taxiway U.

At 1104:30, the ground controller, unaware of the lead tug driver's intentions, observed the tugs on Runway 17R. At that time, the ground controller was controlling 4 other aircraft. He asked the tower controller to abort the aircraft's takeoff, and the tower controller gave the abort command at 1104:36 using non-standard phraseology[5] (see Section 1.18.2.3, *Phraseology for safety-critical situations* of this report). The flight crew of flight JZA7124 did not recall hearing the abort takeoff instruction from the tower controller.

A few moments later, the flight crew saw the vehicles on the runway. They continued the takeoff, given that the aircraft was near the decision speed (V_1) and they considered this option to be the safest course of action. At 1104:39, in summary, the ground controller instructed the tugs to exit Runway 17R onto Taxiway U, to proceed onto Taxiway C, and hold short of Runway 26. The driver of the lead tug read back the instructions.

At 1104:43, the departing aircraft was crossing Runway 29 and had accelerated past V_1. At an approximate lateral distance of 3700 feet from the tugs, the aircraft became airborne. At

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5 When a take-off clearance is being cancelled after the aircraft has begun the take-off roll, the required phraseology is: "(aircraft id), ABORT, ABORT, (aircraft id) ABORT, ABORT [reason]." (Source: NAV CANADA, *Manual of Air Traffic Services – Tower*, version 2.9 (31 March 2023), p. 118.)

1104:53, while the vehicles were exiting Runway 17R via Taxiway U, the aircraft passed over them at a height of approximately 350 feet, and the flight crew continued the flight without further incident.

1.2 Injuries to persons

There were no injuries.

1.3 Damage to aircraft and tugs

There was no damage.

1.4 Other damage

There was no other damage.

1.5 Personnel information

1.5.1 Tug operators

The driver of the lead tug had worked for ATS at CYYC since 2011 as a ramp agent and held an area-specific DA Airside Vehicle Operator's Permit (AVOP)[6] for operations on Apron 1. His current DA AVOP had an expiry date of 01 December 2025. At the time of the occurrence, he was almost 3 years into a 5-year validity period. In addition, he held a DDT-type D-Tow AVOP,[7] which allowed towing operations on specific aprons, taxiways, and runways under direct control of ATC, and granted driving privileges on controlled runways and taxiways.[8] The DDT – Type D-Tow AVOP requires a Restricted Operator Certificate with Aeronautical Qualification (ROC-A) which the lead tug driver held.

The driver of the 2nd tug had been working for ATS at CYYC as a ramp agent for 2 years and possessed a DA AVOP, which had an expiry date of 24 January 2027. This driver did not have the training or authority to operate on controlled areas of the airport and was therefore required to follow the lead tug at all times. Although the 2nd tug was equipped with a radio, its driver did not communicate directly with ATC.

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6 A DA AVOP allows a driver to drive vehicles on aprons and airside roads and tow aircraft on aprons. According to the *AVOP Airside Traffic Directives* for CYYC, "DA AVOP holders may operate on Apron I, III, IV, V, VI VII, VIII, IX and the perimeter roads around the threshold of Runway 17R and Runway 11 in a vehicle that is not equipped with an aeronautical radio." (Source: Calgary Airport Authority, *AVOP Airside Traffic Directives* [revised September 2022], Section 5.2: DA AVOP All Aprons, p. 58.)

7 A D-Tow AVOP includes the DA-type AVOP but also allows a driver to tow aircraft on certain taxiways and runways, according to the agreement between the tow operations company and the airport authority. The 3 types of D-Tow AVOP are the DTN, DTS, and DDT. The DDT-type D-Tow AVOP allows its holder to drive a vehicle unescorted on controlled taxiways and runways, unlike the 2 other types, which only authorize drivers to tow aircraft on specific taxiways and runways. (Source: Ibid., sections 6.1 and 6.4, pp. 72 and 75.)

8 Ibid., Section 6.4: D-Tow AVOPs, p. 75.

1.5.2 Air traffic controllers

Table 1. Air traffic services personnel information

	West ground controller	Combined east/west tower controller
Licence	Air traffic controller	Air traffic controller
Medical expiry date	01 December 2023	01 September 2025
Air traffic services experience	9 years	19 years
Experience in present unit	3 years	15 years
Hours on duty before the occurrence	0.25 hours	2.0 hours
Hours off duty before the work period	15.75 hours	10.25 hours

Three air traffic controllers were in the tower cab at the time of the occurrence. All 3 controllers on duty held the appropriate licence and were qualified for the operation in accordance with existing regulations. The combined west/east tower controller had started his shift at 0900 on 06 October 2023 and had just come back from his 1st break at the time of the occurrence. The west ground controller, who was responsible for the west side of the airport, had started his shift at 1045 and was in his 1st assignment for the day. Around the time of the runway incursion, both controllers were actively looking outside through the tower windows because the A-SMGCS system was unusable. During a controller refresher training event in the winter of 2021 the tower controller had received information on the change in the phraseology for take-off abort events. Following this incursion, there was no follow up by NAV CANADA with the controller on the phraseology used during this occurrence.

1.6 Aircraft and tug information

1.6.1 Aircraft information

Not applicable.

1.6.2 Tug information

1.6.2.1 Douglas-Kalmar TBL-280 Tugmaster

The lead tug was a Douglas-Kalmar TBL-280 Tugmaster towbarless aircraft handling tractor. It is designed primarily for "pushback, inter-gate towing, and longer distance maintenance towing operations at higher speeds, with aircraft with nose wheel weights up to 35 tonnes.”[9]

This tug is capable of docking with and lifting the nose wheel of the aircraft for pushback and towing operations without the need for a towbar or a 2nd person.[10] This style of tug was not suitable for the aircraft that was going to be towed, thus the requirement for the 2nd tug. The turning radius for 2-wheel steering from the front wheels is 39.5 feet and 26.4 feet for 4-wheel steering. At the time of the occurrence, the tug was configured for 2-wheel steering from the front wheels. The tug was equipped with a VHF (very high frequency) radio and transponder, which was required by the Calgary Airport Authority to operate on taxiways and runways.

1.6.2.2 JBT AeroTech B250 aircraft tow tractor

The 2nd tug was a JBT AeroTech B250 aircraft tow tractor with 4-wheel drive. It has the ability to handle aircraft as large as the Airbus 320 and Boeing 737 families of aircraft and was suitable for the task. It also has towbar attachment points on the front and rear. Its turning radius is 18.5 feet in 2-wheel steering mode and 13.3 feet in 4-wheel steering mode. This tug was not equipped with a transponder but was equipped with a VHF radio. It had to follow a transponder-equipped tug (the Douglas-Kalmar TBL-280) while operating on the airport’s movement area.

1.7 Meteorological information

The aerodrome routine meteorological report (METAR) issued at 1100 for CYYC was as follows:

- Winds from 220° true at 4 knots
- Visibility 40 statute miles
- Scattered clouds at 25 000 feet above ground level
- Temperature 10 °C and dew point –3 °C

Weather was not considered to be a factor in this occurrence.

1.8 Aids to navigation

Not applicable.

1.9 Communications

All communications equipment used by the tug drivers, air traffic controllers, and flight crew involved in the incident functioned normally. The communication radios in both tugs were operational.

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[9] Douglas Equipment, Specification NS.1758, Douglas-Kalmar TBL-280 Tugmaster Towbarless Aircraft Handling Tractor, Issue 8, p. 2.

[10] Ibid.

1.10 Aerodrome information

CYYC has 4 runways (08/26, 11/29, 17R/35L, and 17L/35R), numerous taxiways, and 10 aprons. NAV CANADA is the provider of air and vehicle traffic services on the manoeuvring areas[11] at the airport.

In 2023, CYYC was ranked Canada's 4th busiest airport by passenger traffic, handling 18.5 million passengers that year.[12]

1.10.1 Taxiway C2 markings and signs

The runway holding position marking used on Taxiway C2 is of the pattern A variety[13] and features an enhanced taxiway centreline marking leading up to it. In addition, there are runway identification signs, along with elevated runway guard lights, on opposite sides of the runway holding position marking where Taxiway C2 joins with Runway 17R. A red rectangle with the runway designation marking (runway number and letter) painted in white letters is collocated with the runway holding position marking on the taxiway entrance to the runway (Figure 3).

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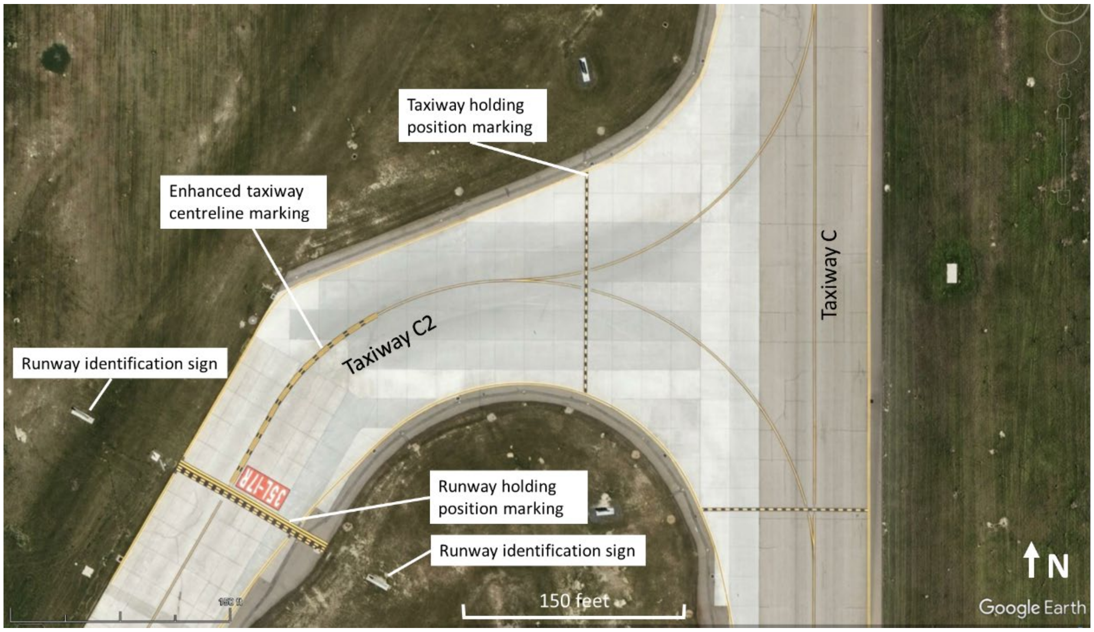
11 The manoeuvring area is "that part of an aerodrome, other than an apron, that is intended to be used for the take-off and landing of aircraft and for the movement of aircraft associated with take-off and landing." (Source: Transport Canada, SOR/96-433, *Canadian Aviation Regulations*, section 101.01.)

12 YYC Calgary International Airport, "Key facts and figures," at https://www.yyc.com/en-us/about-us/facts-figures (last accessed on 04 April 2025).

13 Transport Canada, TP 312E, *Aerodromes Standards and Recommended Practices*, 5th Edition (revised 15 January 2020), Section 5.2.16: Runway-Holding Position Marking, Figure 5-12: Runway-holding position markings, page 114.

Figure 3. Taxiway C2 markings and signage (Source: Google Earth, with TSB annotations)



The Calgary Airport Authority's *AVOP Airside Traffic Directives* describes the following as it relates to runway holding position markings:

> Runway Holding Position markings consist of two solid and two broken yellow lines across the width of a Taxiway with the broken lines closest to the Runway to indicate a Runway holding position. Vehicles must STOP [emphasis in original] behind the solid lines with enough room to turn around. Both vehicles and aircraft cannot proceed across Runway Holding Position Markings until given permission to do so by Calgary Ground. (Some Runway holding position markings are straight lines while others are bent lines).[14]

1.11 Flight recorders

The De Havilland Aircraft of Canada Limited DHC-8-400 aircraft, which was taking off from Runway 17R at the time of the runway incursion, was equipped with a digital flight data recorder and a cockpit voice recorder. The cockpit voice recorder data of the event were overwritten, and the data from the digital flight data recorder were not required by the investigation given that information on the positions of both the tugs and the aircraft was available.

1.12 Wreckage and impact information

Not applicable.

[14] Calgary Airport Authority, *AVOP Airside Traffic Directives* (revised September 2022), Section 4.9.3: Runway Holding Position Markings, p. 49.

1.13 Medical and pathological information

There was no indication that the performance of the individuals involved in the occurrence was affected by medical or physiological factors, including fatigue.

1.14 Fire

There was no fire.

1.15 Survival aspects

Not applicable.

1.16 Tests and research

1.16.1 TSB laboratory reports

The TSB completed the following laboratory report in support of this investigation:

- LP148/2023 ATS Radar and Audio Analysis

1.17 Organizational and management information

1.17.1 Calgary Airport Authority Airside Vehicle Operator's Permit program

The *Canadian Aviation Regulations*[15] require airport operators to ensure that duties in areas where aircraft operate are only assigned to employees who have successfully completed safety related training. The AVOP program at CYYC allows qualified individuals to drive a vehicle on the airside[16] of an airport, beyond or outside of any leased area.

To obtain an AVOP, an applicant must:

- hold a valid driver's licence (minimum Class 5[17] or equivalent);
- hold a valid restricted area identification card for the employer (company) specified on the AVOP;
- pass both a written and a practical test; and
- sign and submit an AVOP application form, which is also signed by the employer of the applicant (the employer requesting authority must be a company manager with signing authority for company AVOPs).[18]

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15 Transport Canada, SOR/96-433, *Canadian Aviation Regulations*, paragraph 302.07(1)(g).

16 Airside is "[t]he movement area of an airport, including adjacent terrain and buildings or portions thereof, where access is controlled." (Source: NAV CANADA, Terminav terminology database)

17 In the province of Alberta, a Class 5 driver's licence allows drivers to drive most cars, trucks, or vans by themselves.

18 Calgary Airport Authority, *AVOP Airside Traffic Directives* (revised September 2022), Section 3.2: Application for an Airside Vehicle Operator's Permit (AVOP), p. 15.

The renewal for the AVOP is similar to the initial application.[19]

AVOPs are company-specific, and all training at the time of the occurrence was done through ATS, with applications and the test results submitted to the AVOP administration office of the Calgary Airport Authority. Practical testing for the DA AVOP was completed by ATS and for the D-Tow AVOP by a third party contracted by the Calgary Airport Authority.

The investigation determined that there were training modules completed by the tug drivers, as required by their employer, ATS, and one of its clients, WestJet Airlines Ltd. (WestJet), that covered the equipment used in ramp operations. In addition, ramp agents, including the tug drivers, had to meet further on-the-job components while working with examiners from the client company who were specialists in the type of aircraft the ramp agents were required to move. However, no recurrent training was provided regarding the necessary body of knowledge for the possession of a valid DA or D-Tow AVOP.

1.17.2 Airport Terminal Services

The planned aircraft movement in this occurrence was of a WestJet aircraft. At the time of the occurrence, ATS held a contract under which it was responsible for providing the necessary services for WestJet's ground operations at CYYC, including the movement and towing of aircraft on all aprons, taxiways, and runways, as well as WestJet's hangar.

Although ATS did not have a formal system to manage safety, it did comply with its clients' safety management systems (SMSs). ATS had signed an agreement with WestJet stipulating that, should events occur while ATS vehicles are towing a WestJet aircraft, they would report these events through WestJet's SMS.

The tug drivers involved in the occurrence were unaware of any requirement to report safety-related events into any system.

Shortly after the occurrence, the contract between ATS and Westjet ended as planned, and ATS ceased to move aircraft for WestJet at CYYC.

1.17.2.1 Airport Terminal Services training program

ATS' training for the DA AVOP and D-Tow AVOP involves computer-based training and on-the-job training (OJT). The computer-based training and OJT programs are coordinated to teach effective communication and towing techniques. A trainee rides along with a trainer until both feel that the trainee is proficient. A practical test is administered by ATS for the DA AVOP to certify the trainee to tow aircraft and by a third party for the D-Tow AVOP. If the trainee is unsuccessful, more OJT is conducted until the trainee is assessed as ready to attempt the practical test once again, to a maximum of 3 attempts. For daytime operations, DA and D-Tow AVOP holders receive no further training and are subjected only to the

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19 Ibid., Section 3.3.8: Renewals, p. 18.

written and practical renewal tests every 5 years[20] to ensure proficiency. For nighttime operations, a separate mandatory competency check must be completed within 180 days of the initial practical test for the DA and D-Tow AVOP.

Although ATS' training program for ground vehicle operators, including tug operators, covers the basic procedures for communications with ATC, ATS ground vehicle operators receive minimal training on managing their relationship with ground controllers, who are the authority figures in ground operations, and how to interact with them when complex or unusual situations arise.

In ATS' training material, the only direct reference to a situation involving a problem with communications from ATC, for example, appears in a final bullet on a single slide in one of ATS' online learning resources. It advises ground vehicle operators to reply "Say again" if they find an instruction issued by a controller unclear.[21] In contrast, the Calgary Airport Authority's *AVOP Airside Traffic Directives* cover the topic of how to interact with ATC[22] in different scenarios, including runway crossings where ensuring accurate communications with ATC is vital.

1.18 Additional information

1.18.1 NAV CANADA

1.18.1.1 Advanced surface movement guidance and control system

Controllers visually scan the airfield at CYYC, which involves shifting their attention from situation to situation and back again to ensure that aircraft and vehicles are manoeuvring as instructed. To enhance this process, the airport is also equipped with a Level 1 A-SMGCS, which provides control tower personnel with a real-time display of aircraft and vehicle traffic operating on airport manoeuvring areas.

The International Civil Aviation Organization defines A-SMGCS as follows:

> A system providing routing, guidance and surveillance for the control of aircraft and vehicles in order to maintain the declared surface movement rate under all weather conditions within the aerodrome visibility operational level (AVOL) while maintaining the required level of safety.[23]

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20 At the time of the occurrence the Calgary Airport Authority, *AVOP Airside Traffic Directives* was being revised. The new edition was released on 01 November 2023. This revised edition includes an amendment that reduces the renewal period for an AVOP from 5 years down to 3 years.

21 Airport Terminal Services, *Towing and ATC Communications*, V2 (August 2014), p. 17.

22 Calgary Airport Authority, *AVOP Airside Traffic Directives* (revised September 2022), Section 7.0: Air Traffic Control and Radio Procedures, pp. 78-96.

23 International Civil Aviation Organization, document no. 9830 AN/452, *Advanced Surface Movement Guidance and Control Systems (A-SMGCS) Manual*, First Edition (2004), Glossary, p. ix.

The A-SMGCS incorporates information provided by the multilateration (MLAT) system and the surface movement radar (SMR). The MLAT system uses a network of ground sensors to receive signals from transponders mounted in aircraft and vehicles and thus provides an additional layer of ground surveillance with full airport coverage. The MLAT system calculates the position of a vehicle or aircraft by interrogating its transponder from multiple antennas. The MLAT information is then integrated with SMR data to depict surface traffic pictorially on controllers' display.[24]

According to NAV CANADA's *Calgary Control Tower Unit Operations Manual*, all aircraft are expected to keep their transponders on when manoeuvring on aprons, taxiways, and runways.[25] Aircraft that have not previously received a transponder code from air traffic services are to use transponder code 1000. If an aircraft is equipped with a mode S transponder,[26] the civil registration number of the aircraft will be displayed on the display. Ground support equipment vehicles, including tugs, that leave Apron 1 are equipped with a vehicle transponder, which is interrogated by the MLAT system and, in turn, displayed on controllers' screens. These vehicle transponders do not have the ability to change frequency. When one is installed, the unit broadcasts a code unique to that vehicle and is registered with the airport authority and with NAV CANADA.

1.18.1.1.1 Virtual stop bar

Built into the A-SMGCS at CYYC is a feature called a virtual stop bar. Stop bars are mandatory for reduced- and low-visibility operations and optional for regular operations. According to the *Calgary Control Tower Unit Operations Manual*,

> [t]o enhance safety during poor visibility the A-SMGCS is configured with virtual stop bars, which are located in the vicinity of the physical hold lines. Virtual stop bars **reduce the potential for runway incursions** [emphasis added][**27**] by sounding an alarm when an aircraft enters (or crosses) a runway without first disabling the stop bar. These stop bars are truly 'virtual' and only depicted on the A-SMGCS presentation. Air crew and vehicle operators will have no indication that ATC is using this feature.
>
> Aircraft that have landed (or are on the runway) and exit will not trigger an alarm. To reduce the number of false alarms the virtual stop bars are located just beyond the hold lines.[28]

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24 NAV CANADA, *Calgary Control Tower Unit Operations Manual* (amended 15 June 2023), p. 71.

25 Ibid.

26 Mode S transponders have data link capabilities for the transfer of additional information.

27 To prevent nuisance alarms, A-SMGCS virtual stop bars are designed to activate after an aircraft has crossed a hold line. The virtual stop bars are designed to alert controllers of an incursion and allow the controller time to instruct the aircraft/vehicle to stop before entering the actual runway and, therefore, reduce the severity of the consequence of the incursion.

28 NAV CANADA, *Calgary Control Tower Unit Operations Manual* (amended 15 June 2023), p. 56.

1.18.1.2 Procedures for when the advanced surface movement guidance and control system is unavailable

The primary tool employed by controllers in the Calgary control tower for the separation of runway traffic is the visual scan. A-SMGCS is deemed a support tool and assists controllers when they cannot see a manoeuvring surface.

A-SMGCS outages at CYYC are generally infrequent; however, there are procedures in place to address such situations. In the case of an A-SMGCS outage, the control tower supervisor advises the Calgary Airport Authority, the NAV CANADA duty manager in the Edmonton Area Control Centre, and the Calgary terminal control unit. The supervisor ensures that arrival and departure controllers are briefed and aware of changes to operations and that the necessary defences are put in place. In addition, the *Calgary Control Tower Unit Operations Manual* provides the following recommendations for tower operations:

> **A. Restriction of vehicle and aircraft traffic**
>
> When visibility results in the controller being unable to see any portion of a manoeuvring area and the SMR is unserviceable, vehicle and aircraft movements should be restricted. The Tower Supervisor (or designate) shall notify the Airport IOC [Integrated Operations Manager] that vehicle movements:
>
> - are restricted to those essential for airport operations; and
> - all vehicle operations require ATC clearance to operate on manoeuvring areas
>
> **B. Suggested operating practices**
>
> The following best practices should be considered during a SMR outage:
>
> - Controllers must remain vigilant with good airfield scanning and EXCDS [Extended Computer Display System] practices.
> - Ground must ensure to provide Tower a secure sequence of departures on EXCDS and continue to use best practices in the Ground Taxiing bay to keep track of traffic.
> - If aircraft are not visible from the tower:
>   - Arrivals - request the pilot to report clear of the runway.
>   - Departures - request the pilot to report rolling. (will aid in lining up subsequent aircraft)
>   - Request position reports during taxi, especially if a potential conflict exists.[29]

The manual goes on to recommend the segregated mode for arriving and departing aircraft during day operations in visual flight rules weather:

> VFR WX Day Operations - Segregated [Runways] 35s/17s
>
> - depart [Runway] 35L/17R and arrive [Runway] 35R/17L with 6 – 7 offloads allowed per hour

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29 Ibid., p. 70.

> - spacing: 4 NM on 35R/17L and 20 NM on 35L/17R
>
> […]

Coordination of reduced spacing for individual aircraft or very short time periods may be considered when departure demand is very low, and workload permits.[30] The addition of a controller constitutes another possible strategy for mitigating the impact of an A-SMGCS outage. For instance, the *Calgary Control Tower Unit Operations Manual* outlines a non-routine operation called Chinook 29, which is used when Runway 29 is active. During this operation, a monitor, who sits between the west tower and west ground positions, assists the west ground controller. The monitor controller is responsible for, among other duties, maintaining a listening watch on the west ground frequency, monitoring for correct readbacks from aircraft and vehicles (and notifying the west ground controller of any discrepancies), and alerting the west ground and west tower controllers of any vehicles or aircraft that deviate from instructions in a manner that may pose a risk to safety.[31]

1.18.1.3 Phraseology for safety-critical situations

In the event of a serious runway incursion, a controller may decide that the safest course of action is to issue an instruction to a departing aircraft to abort takeoff. Such instructions, particularly with respect to aborting a takeoff, are not common but are considered only as a last resort option. The guidance in NAV CANADA's *Manual of Air Traffic Services* states:

> Aborting a takeoff is an emergency procedure used when continuing would present a grave hazard to the aircraft. A controller-initiated aborted takeoff is an extreme measure used only where no clear alternative exists.[32]

When the tower controller issued the instruction to abort the takeoff, the phraseology required by the *Manual of Air Traffic Services* was not used. Phraseology for safety-critical situations was identified as a safety issue in TSB Air Transportation Safety Issue Investigation Report A17O0038. In part, the report identified that when air traffic controllers recognize a conflict between aircraft or vehicles they must issue prompt instructions to resolve the conflict. These instructions need to be recognized and understood by the intended recipients so that the safest course of action can be taken. If these instructions are not actioned, there is a risk that the conflict may result in a collision. As a result, the TSB recommended that

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[30] Ibid., pp. 70-71.

[31] Ibid., p. 73.

[32] NAV CANADA, *Manual of Air Traffic Services – Tower*, version 2.9 (31 March 2023), p. 118.

NAV CANADA amend its phraseology guidance so that safety-critical transmissions issued to address recognized conflicts, such as those instructing aircraft to abort takeoff or pull up and go around, are sufficiently compelling to attract the flight crew's attention, particularly during periods of high workload.

TSB Recommendation A18-04

In response to Recommendation A18-04, in October 2019, NAV CANADA amended its abort take-off phraseology to include repetition as a method to ensure that the instructions are significantly compelling to be recognized during periods of high workload, such as takeoff. In March 2020, the TSB considered the action taken by NAV CANADA to be effective at reducing the risk, and closed the recommendation with a **Fully Satisfactory** rating.

1.18.2 Mental models

Humans make decisions in part by building a mental representation of the way the world works, and this is referred to as a mental model. It has been established that "[t]he function of such models is to order the knowledge of the work so as to allow the practitioner to make useful inferences about what is happening, what will happen next, and what *can* [emphasis in original] happen."[33] This model is developed over time, via both formal means, such as training, and informal means, such as on-the-job experience.

Mental models do not typically mirror the exact components and functionality of a particular system, given the amount of information that would be required to do so.[34] However, the mental representation is often accurate enough and reduces cognitive demands to facilitate more efficient decision making. Inaccurate information or gaps in understanding can "creep" into a mental model, and when they do, actions based on this inaccurate model are incorrect when applied to the associated real-life situation.

In addition, when considering the application of mental models within a team, it is possible that team members can hold mental models that are incongruous with those of other team members. This can result in erroneous actions being made because of different understandings of a particular situation and the need for more communication between team members.

Increased learning and understanding among team members (regardless of their levels of authority) about their different roles, perspectives, and work environments can help reduce the negative effects caused by conflicting mental models. For instance, the Calgary Airport Authority frequently conducts outreach activities with NAV CANADA to facilitate information sharing between the different staff members involved in ensuring safe ground operations at the airport. However, many ground vehicle operators do not benefit from

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33 D. Woods, S. Dekker, R. Cook, et al., *Behind Human Error*, 2nd ed. (Ashgate Publishing, 2010), p. 104.

34 Ibid.

these activities because their organization's safety management activities are managed by the airlines they service and not by the airport authority.

1.18.3 Authority gradient

Authority gradient refers to the balance of perceived authority between the designated leader in a team and that person's team members.[35] This gradient is influenced by a variety of factors that include but are not limited to age, gender, experience, and reputation.

An optimal authority gradient is present when there is a clear understanding of who the leader is (e.g. the captain) and when all team members are able to contribute to the decision-making process and feel comfortable doing so.[36] In this environment, the leader is responsible for ensuring that all guidance provided is clear and understood; however, if, while communicating important information, this person omits information or makes a mistake, as a result of a lapse of memory or a slip of attention, it is essential that others within the team ask for clarification without being hesitant to do so.

A gradient that is too steep implies an authoritarian type of leadership style, where either the leader ignores input from team members or those same team members do not feel comfortable speaking up. By contrast, in a gradient that is shallow, a leader has ceded too much authority and is no longer in control of the team.[37] When a suboptimal authority gradient negatively impacts performance, such as in these 2 examples, the outcome is typically a breakdown of crew resource management practices where communication is hindered and sound decision making is inhibited. Teams that are organized according to either a shallow or steep authority gradient can require extensive teamwork development and team-building training to adjust the gradient and, therefore, improve the team dynamics, along with the team's ability to communicate and make decisions effectively.

Authority gradients can exist in multidisciplinary teams as well as in homogeneous ones.[38] For example, as opposed to the pilot-pilot team in a cockpit, ground operations at an airport involve several different professionals, such as pilots, ground controllers, vehicle operators, and ground crew members, all of whom must work together as a team to ensure the safe and efficient movement of air traffic. In this environment, a steep authority gradient would likely be even more challenging to overcome because the team members are dispersed (i.e., part of different organizations and physically distanced), and the differences in their roles in ground operations inherently create a much steeper gradient than that of a single-discipline team, such as the flight crew of an aircraft. In particular, the role of a ground controller

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35 E. Seedhouse, A. Brickhouse, K. Szathmary, and E.D. Williams, *Human Factors in Air Transport: Understanding Behavior and Performance in Aviation* (Springer, 2020), Chapter 8: Training, Section 8.1.3: Transcockpit Authority Gradient, p. 140.

36 Ibid.

37 Ibid.

38 B. Luva and A. Naweed, "Authority gradients between team workers in the rail environment: a critical research gap", *Theoretical Issues in Ergonomics Science*, Vol. 23, Issue 2 (2022), p. 157.

versus that of a vehicle operator presents a steep authority gradient. This steep gradient can sometimes be manifested in vehicle drivers' uncertainty about whether to ask for clarification when they find controllers' instructions unclear, which can lead the vehicle drivers to interpret and act on these instructions, despite any gaps in understanding.

While in this occurrence the lead tug driver did query the ground controller when he was uncertain of the instruction to enter Taxiway C2, the investigation was informed of other events where ground vehicle operators at CYYC did not query when there was unclear communication as a result of the negative effects of a suboptimal authority gradient. The Calgary Airport Authority recognizes these effects and has several mitigations in place, including, but not limited to, communication protocols and standard operating procedures, training, reporting mechanisms for both ground vehicle operators and air traffic controllers, as well as regular meetings with NAV CANADA to discuss safety issues. NAV CANADA also has employed mitigations to reduce the risk of miscommunications between controllers and ground vehicle operators, such as with the development of its *Ground Traffic Phraseology*[39] guide that contains guidance on how to manage communications with controllers.

1.18.4 Currency and minimum level of proficiency

Maintaining currency is a fundamental aspect of safety in aviation, which includes operations at airports. It means that the knowledge and skill level required to obtain a licence or rating and exercise their privileges are still retained by the person who holds them, even after a certain amount of time has passed, such that they remain proficient and capable of handling the complex and dynamic challenges of aviation.

For example, the Transport Canada publication *How to Stay Current*[40] details how pilots must meet the requirement for recent experience by breaking it down into 3 time periods. There is a 6-month, 2-year, and 5-year timeframe during which pilots must complete specific flight activities and training covering different aspects of their licence in order to exercise its privileges. However, meeting these currency requirements only ensures that a minimum level of pilot proficiency is achieved. Transport Canada recognizes that for pilots to be proficient, ongoing training needs to be successfully completed so that they can function as expected in the aviation environment.

In contrast, the Calgary Airport Authority's AVOP program does not have any currency requirements for airside vehicle operators. In the 5 years between the issuance of an AVOP for daytime operations and its expiry, the AVOP holder is not required to demonstrate that he or she has remained current and retained the level of knowledge required to obtain the permit.

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[39] NAV CANADA, *Ground Traffic Phraseology*, Version 3 (April 2002), at https://www.navcanada.ca/en/ground-traffic-phraseology.pdf (last accessed on 26 June 2025).

[40] Transport Canada, TP 2228E-37, *Take five… for safety: How to Stay Current* (January 2010), at https://publications.gc.ca/collections/collection_2010/tc/T52-4-2228-37-eng.pdf (last accessed on 26 June 2025).

1.18.5 Procedures, adaptation, and work

Procedures are applied by experienced, trained individuals in the real world. Procedures exist to provide standardization and to describe task steps; however, sometimes there can be mismatches between procedures and the work practices.[41,42] A mismatch creates a gap between how work is written into a procedure and how it gets done in real life. This gap creates opportunities for work to be adapted when reconciling multiple goals such as working safely, getting the job done, and complying with regulations.[43]

An absence of familiarization, recurrent training, and routine compliance checking on how work is done in daily operations can increase the likelihood of adaptations that drift away from established procedures. The longer an adapted work practice is applied without incident, the more established the adapted work practice becomes.[44] Over time, the new and adapted way of working becomes the normal way of working and crew members new to the operation adopt these adaptations as the standard practice instead of following the actual procedure.

A risk in these circumstances is that an adapted practice might not have considered all the hazards associated with the work and local environment, as well as the mitigations that are designed into a formal procedure to manage those risks. The adapted practice may miss key safety requirements or coordination with other procedures while it still accomplishes the work. These natural, incremental adaptations to accomplish work tasks in complex work environments and conditions can imperceptibly erode safety margins.[45]

1.18.6 TSB Watchlist

The TSB Watchlist identifies the key safety issues that need to be addressed to make Canada's transportation system even safer.

The risk of collisions from runway incursions is a Watchlist 2022 issue. As this occurrence demonstrates, personnel driving on airport ramps and taxiways may not have the required knowledge to safely operate equipment and carry out their responsibilities if they do not receive proper recurrent training.

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41 A. Degani, and E.L. Weiner, *On the Design of Flight-Deck Procedures* (NASA Ames Research Center: June 1994), p. 2.

42 S. Dekker, "People as a Problem to Control," *Safety Differently: Human Factors for a New Era*, 2nd Edition (CRC Press: 2015), pp. 79-114.

43 R. Cook, and C. Nemeth, "Taking things in one's stride: Cognitive features of two resilient performances," in E. Hollnagel, DD. Woods, and N. Leveson (eds.), *Resilience engineering: Concepts and precepts* (Ashgate Publishing: 2006) pp. 205-220.

44 J. Rasmussen, "Risk management in a dynamic society: A modelling problem," *Safety Science*, Vol. 27, No. 2/3 (1997), pp. 183-213.

45 S. Dekker, *Drift into Failure: From HuntingBroken Components to Understanding Complex Systems* (CRC Press: 2011), pp. 112-115.

ACTION REQUIRED

Reducing the risk of runway incursions is a complex issue and requires collaboration from all sectors of the air transportation industry. There is no single solution that will reduce the risk of runway incursions nationwide. Rather, solutions tailored for each airport, in combination with wider-reaching technological advancements such as in-cockpit situational awareness aids and runway status lights, may be more effective.

The **risk of collisions from runway incursions** will remain on the TSB Watchlist until

- effective defences to prevent runway incursions are implemented in incursion hotspots; or
- the rate of runway incursions demonstrates a sustained reduction, and the number of high-risk incursions continues to show a sustained reduction.

2.0 ANALYSIS

The investigation did not reveal any mechanical or technical malfunction in the aircraft tow vehicles (tugs) that could have contributed to the runway incursion. The pilots, air traffic controllers, and lead tug driver involved in the incursion all held the appropriate licences, ratings, and/or permits for the work being performed, with no indications that performance had been degraded by medical factors or fatigue.

The analysis will therefore focus on the training and proficiency of the lead tug driver, the differing mental models of the situation held by the ground controller and the lead tug driver, and the authority gradient that exists between air traffic controllers and ground vehicle operators. The analysis will also look at which defences were put in place by NAV CANADA air traffic services staff at Calgary International Airport (CYYC), Alberta, when the advanced surface movement guidance and control system (A-SMGCS) was taken offline for planned maintenance. Lastly, the analysis will discuss air traffic controller phraseology in safety-critical situations.

2.1 Recurrent training and proficiency of tug operators

The lead tug driver in this occurrence possessed a DDT-type D-Tow Airside Vehicle Operator's Permit (AVOP), which grants specific driving and aircraft-towing privileges on the airfield. The DDT-type D-Tow AVOP required the lead tug driver to obtain a Restricted Operator Certificate with Aeronautical Qualification (ROC-A), which is valid for life. Once the lead tug driver possessed a ROC-A, he could then study the additional material needed to pass the test to obtain the DDT-type D-Tow AVOP. Like the DA AVOP, this AVOP also has a 5-year validity period.

However, these permits and certificates, once issued, do not have any recency requirements within their validity periods. The different types of AVOPs do not require recurrent training related to the essential knowledge and skills that applicants must possess to pass the necessary tests and obtain the permits and certificate, respectively. Individuals who hold these are not required to revisit any of the material covered or demonstrate, after a certain period of time, that they still know and can apply it. The Calgary Airport Authority AVOP program does not feature a recency training component. Airport Terminal Services, the tug drivers' employer, did have an annual training program in place for tug drivers, but it related to the equipment being used and serviced on the ramp rather than to the required knowledge for operation in compliance with the AVOP.

In this occurrence, the lead tug driver stopped too close to the runway holding position marking and did not have enough room to turn around, even though the Calgary Airport Authority's *AVOP Airside Traffic Directives* require that vehicles leave enough room to turn around. This practice is likely the result of a procedural adaptation where, over time, the driver began stopping at the clearest visual cue for the task—the runway holding position marking itself—as opposed to further back from the cue, because in most cases, the controller would instruct the driver to proceed. This is also an example of a procedure that was written in a general sense and required interpretation on the part of the driver to know what constituted enough room based on the vehicle they were driving. Without a recurrent training program focused on procedural elements and an oversight process (such as proficiency checks) that monitors for drift away from procedures over time, it is easy for these types of adaptations to go unidentified and uncorrected.

The lead tug driver involved in this occurrence was nearly 3 years through the 5-year cycle for both his DA AVOP and his DDT-type D-Tow AVOP and, throughout the course of his work since obtaining these permits, had received no recurrent training related to the knowledge required to obtain them and, as a result, his practice had drifted away from defined procedures. This drift was likely due to a need for recurrent training targeted specifically at the knowledge of the *AVOP Airside Traffic Directives*, as well as a need for more oversight on vehicle drivers' adherence to airside driving procedures.

Finding as to causes and contributing factors

Due to procedural drift from an absence of recurrent training and oversight, the lead tug driver stopped too close to the Taxiway C2 runway holding position marking, which did not leave enough room for the vehicle to turn around as required by the *AVOP Airside Traffic Directives*.

2.2 Decision to enter Runway 17R

Before the runway incursion occurred and while the 2 tugs were travelling south on Taxiway C toward their destination, the ground controller instructed the lead tug driver to move onto Taxiway C2, hold short of Runway 17R, remain clear of Taxiway C while an aircraft travelling north on that taxiway passed by, and then proceed on Taxiway C again. During this series of instructions, the lead driver's mental model of the situation was in conflict with the ground controller's mental model and, by extension, with the ground controller's expectation of what the lead driver would do based on these instructions.

The lead driver's mental model consisted of several elements that made entering Runway 17R, for the purposes of rejoining Taxiway C, appear to be the right choice in that moment. When he received the instruction from the ground controller to enter Taxiway C2 and hold short of Runway 17R, his interpretation of this instruction was that the 2 tugs were required to proceed all the way to the runway holding position marking and stop immediately short of it. This action was inconsistent with the procedure in the Calgary Airport Authority's *AVOP Airside Traffic Directives* for approaching runway holding position markings, which stipulates that a driver must stop in a position in which there is enough space to turn around. However, the driver's action was likely a practice that logically arose from the fact that an instruction to hold short of a runway is almost always followed by an instruction to continue on that route onto the runway and not to turn around. Additionally, the driver had never turned around on a taxiway before and believed this was not allowed. It therefore made sense to the lead tug driver to wait immediately short of the runway holding position marking, based on, and in anticipation of, what he typically experienced after this kind of instruction from air traffic control (ATC).

As a result of where he had stopped while waiting for the taxiing aircraft to pass, he did not feel he was able to turn around once the instruction to proceed on Taxiway C was received. The area on Taxiway C2 around the runway holding position marking is a narrow space (approximately 88 feet wide) and given the lead tug driver's turning radius while in 2-wheel steering mode (39.5 feet), the space appeared inadequate to the lead driver for the purposes of accomplishing the manoeuvre. Furthermore, he did not deem backing up an option because it would have required both drivers to exit their vehicles and disconnect the towbar from the 2nd tug. The lead tug driver also had a strong belief that, unless explicitly instructed by the controller to do so, drivers were not supposed to turn around while driving on controlled airport surfaces, such as taxiways and runways, and that this would require specific instructions from the controller. Therefore, all of these elements resulted in his conclusion that turning around was not a viable option.

The route that did appear to make sense to the lead tug driver was to enter Runway 17R and immediately navigate back onto Taxiway C via Taxiway U. This option was all the more reasonable to him because it involved making a short detour onto a runway, a manoeuvre with which he was familiar, having done something similar on several occasions during the summer while construction was being conducted near Runway 29. He also felt that the ground controller would be able to see what he and the other driver were doing and stop them if their actions were not acceptable.

The ground controller's mental model of the same situation was different. He believed that the tug drivers would follow instructions exactly as provided. In addition, when the lead tug driver gave the ground controller a correct readback of the instruction that had been communicated, this confirmed to the ground controller that the instruction had been understood. Together, both of these shaped the controller's expectation that the subsequent instruction to proceed onto Taxiway C would be followed.

It is difficult for controllers to monitor every movement to its conclusion, but they check the movements they are managing to ensure compliance with their instructions. In this case, the ground controller's expectation that his instruction to the lead tug driver would be followed allowed the ground controller to shift his focus to other aircraft and vehicles.

Finding as to cause and contributing factors

The ground controller's mental model was that the lead tug driver would continue the route the controller had instructed. This was contradictory to the lead tug driver's mental model in which the only way to continue the route was to enter Runway 17R; this mental model had been shaped, in part, by his proximity to the runway holding position. Consequently, the driver misinterpreted the instructions of the ground controller and entered Runway 17R while the departing aircraft was beginning its take-off roll, resulting in a risk of collision.

2.3 Authority gradient

The authority gradient between air traffic controllers, including ground controllers, and ground vehicle operators is inherently steep. This gradient is due to the differing nature of their roles. An air traffic controller develops a mental picture of and monitors all of the vehicles operating within his or her area of control and is tasked with ensuring the safe and efficient movement of those vehicles, whereas a ground vehicle operator is responsible solely for the vehicle he or she is driving and following the controller's instructions. However, the ground vehicle operator must seek clarification if a controller's instruction is either unclear or perceived to be inaccurate.

In general terms, even though controllers act as the leader in this environment, they are still required to work with others as a team. This involves ensuring that all personnel driving on airport surfaces have a clear understanding of what they are being instructed to do. Though well trained, controllers are susceptible to slips of attention or memory lapses that result in erroneous or incomplete information being relayed to other members of the team. If a ground vehicle operator hears an instruction that is either unclear or missing information, it is important that he or she feel comfortable requesting clarification regarding the intent of the controller's instruction. This represents an optimal level of gradient between the leader (the controller) and the team member (the ground vehicle operator). However, the authority gradient between the 2 is, in reality, much steeper. As a result, some ground vehicle operators feel uncomfortable raising this type of issue with controllers, which can lead to potentially unsafe situations in which ground vehicle operators try to make the instruction work even though they may lack the specific clarity or intent of the controller.

The ground vehicle operators working at Airport Terminal Services received minimal training to manage their relationship with controllers. In the training they received from their employer, the only direct reference to resolving an unclear ATC instruction was guidance advising ground vehicle operators to reply "Say again." The *AVOP Airside Traffic Directives* do contain helpful information for ground vehicle operators about how to interact with ATC in these situations; however, such written directions would likely not be sufficient to mitigate the effects of a steep authority gradient.

There is also value in controllers learning about some of the practices that ground vehicle operators employ to complete their work, so that controllers could have at least some understanding of how their instructions might be interpreted or actioned by these operators. The Calgary Airport Authority does conduct frequent outreach activities with NAV CANADA to facilitate this kind of information sharing; however, before this occurrence, many ground vehicle operators did not have this opportunity owing to the fact that their organization's safety management activities were managed by the airlines they serviced and not by the airport authority.

In a team situation, such as in this occurrence, which involves many team members, it is important that they are able to communicate and that they feel comfortable to engage with a leader when they believe the clarity or safety of an instruction is in question; otherwise, actions that go against the leader's intentions might be taken.

Finding as to risk

If the authority gradient between an air traffic controller and a ground vehicle operator is not proactively managed, a ground vehicle operator may not feel comfortable asking for clarification if he or she considers an instruction to be unclear or erroneous. This could potentially result in an operator taking actions that differ from those intended by an air traffic controller.

2.4 Defences during outages of airport surveillance equipment

The A-SMGCS provides the controller with the ability to survey the ground movements on the airport surface with real-time display of aircraft and vehicle traffic, particularly in areas that are hard for the controller to see. At CYYC, the A-SMGCS is also configured with the virtual stop bar feature, which is mandatory for reduced- and low-visibility operations and, although not commonly used, optional for regular operations. Virtual stop bars sound an alarm in A-SMGCS when an aircraft or vehicle enters a runway or crosses a runway holding position marking, unless this alarm is disabled. This feature, which sends no notifications to aircraft or vehicles, is used by ATC to help reduce the severity of the consequences should a runway incursion occur.

When the A-SMGCS was taken offline for a software update, the controllers did not have the real-time display to show aircraft and vehicle traffic on the airport. Therefore, they relied solely on visually scanning their areas of responsibility; in this case, the west ground controller was responsible for the west side of the airport. To address the unavailability of A-SMGCS to assist the controllers, Segregated Plus, a mitigation against runway incursions, was activated, increasing spacing for arriving and departing aircraft and designating Runway 17L for landings only and Runway 17R for takeoffs and landings. The intent was to allow the controllers more time to scan the field for movements, issue appropriate instructions and clearances, and confirm correct readbacks.

During this A-SMGCS outage and while Segregated Plus was being used, 26 seconds elapsed from the time the tugs crossed the hold line to the time the controller looked back at the 2 tugs and observed that they had entered Runway 17R. In that time the ground controller was performing other controlling activities.

When technological support tools, such as A-SMGCS, are unavailable to controllers, a number of mitigation strategies can be used to supplement visual scanning. A change to operations, such as implementing Segregated Plus at CYYC, by itself might not be enough to sufficiently reduce any risk, and other strategies, such as staffing an additional controller position, may need to be employed.

At the time of the occurrence, the A-SMGCS and its safety features, such as virtual stop bars, were offline due to a software update.

Finding as to risk

If NAV CANADA relies primarily on additional time and aircraft spacing when A-SMGCS is disabled, making key safety features unavailable, there is an increased risk that hazardous situations such as runway incursions will occur and be detected too late to recover the situation.

2.5 Air traffic control phraseology for safety-critical situations

The take-off and landing phases of a flight are periods of high workload for a flight crew. During periods of high workload, individuals focus most of their attention on the most critical tasks and, as a result, filter or ignore sensory input that they deem less relevant or important.

When the tower controller was alerted to the vehicles on the runway, the abort take-off instruction given to the flight crew of flight JZA7124 was not heard by the flight crew. This was likely due in part to the high workload the flight crew was experiencing during the takeoff. The instruction given by the tower controller was not consistent with the NAV CANADA *Manual of Air Traffic Services*. Although it is impossible to determine what would have happened had the correct phraseology been used, what was said was ineffective as neither flight crew member recalled hearing the instruction to abort the takeoff.

It could not be determined why the controller did not use the current phraseology.

Finding as to risk

If air traffic controllers do not use the correct phraseology for safety-critical situations, there is a risk that the consequences of these situations could be more severe.

3.0 FINDINGS

3.1 Findings as to causes and contributing factors

These are the factors that were found to have caused or contributed to the occurrence.

1. Due to procedural drift over time from an absence of recurrent training and oversight, the lead tug driver stopped too close to the Taxiway C2 runway holding position marking, which did not leave enough room for the vehicle to turn around as required by the *AVOP Airside Traffic Directives*.

2. The ground controller's mental model was that the lead tug driver would continue the route the controller had instructed. This was contradictory to the lead tug driver's mental model in which the only way to continue the route was to enter Runway 17R; this mental model had been shaped, in part, by his proximity to the runway holding position. Consequently, the driver misinterpreted the instructions of the ground controller and entered Runway 17R while the departing aircraft was beginning its take-off roll, resulting in a risk of collision.

3.2 Findings as to risk

These are the factors in the occurrence that were found to pose a risk to the transportation system. These factors may or may not have been causal or contributing to the occurrence but could pose a risk in the future.

1. If the authority gradient between an air traffic controller and a ground vehicle operator is not proactively managed, a ground vehicle operator may not feel comfortable asking for clarification if he or she considers an instruction to be unclear or erroneous. This could potentially result in an operator taking actions that differ from those intended by an air traffic controller.

2. If NAV CANADA relies primarily on additional time and aircraft spacing when A-SMGCS is disabled and key safety features are unavailable, there is an increased risk that hazardous situations such as runway incursions will occur and be detected too late to recover the situation.

3. If air traffic controllers do not use the correct phraseology for safety-critical situations, there is a risk that the consequences of these situations could be more severe.

4.0 SAFETY ACTION

4.1 Safety action taken

4.1.1 NAV CANADA

NAV CANADA has added the abort takeoff phraseology to the Tower Knowledge Verification question bank to ensure tower controllers are examined on this emergency phraseology.

This report concludes the Transportation Safety Board of Canada's investigation into this occurrence. The Board authorized the release of this report on 04 June 2025. It was officially released on 22 July 2025.