Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

AVIATION INVESTIGATION REPORT
A07O0305

RUNWAY INCURSION

R & M AVIATION INC.
LEARJET 35A, N70AX
TORONTO / LESTER B. INTERNATIONAL AIRPORT, ONTARIO
15 NOVEMBER 2007

Canada

Aviation Investigation Report

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Summary

The Learjet 35A aeroplane (registration N70AX, serial number 155) operated by R & M Aviation Inc. was taxiing from the north end general aviation ramp for departure on Runway 06L at Toronto / Lester B. Pearson for Chicago / Rockford, Illinois, United States. The crew of N70AX was instructed to taxi on Taxiway Juliett, hold short of Taxiway Papa, and subsequently to taxi on Taxiway Foxtrot and hold short of Runway 05. At 2206:34 eastern standard time, the aeroplane arrived at the hold position for Runway 05, failed to stop, and, at 2206:43, it entered the runway. At that time, an Israel Aircraft Industries IAI 1124 Westwind aeroplane (registration C-FJOJ, serial number 271), operated by Fast Air, was on the landing roll on Runway 05. The crew of C-FJOJ observed N70AX in front of them and manoeuvred to pass behind it. The two aircraft came within 60 feet of each other.

Ce rapport est également disponible en français.

Other Factual Information

The Learjet N70AX departed from its home base—Aurora, Illinois, United States (U.S.)—at 0953 central standard time (CST) [1] with flight and medical crews on board. The mission was to transport a patient from Miami, Florida, U.S. to Toronto / Lester B. Pearson International Airport (LBPIA). After this, the crew was to return to Aurora by way of Rockford, Illinois, to clear customs. Expected time of return to Aurora was 1700 CST. There were delays due to unanticipated patient handling requirements both at Miami and Toronto. The flight arrived in Toronto behind schedule at 1803 eastern standard time. [2] It departed Toronto at 2220.

Both pilots were certified and qualified in accordance with the U.S. Federal Aviation Administration (FAA) regulations. The pilot-in-command (PIC) was experienced on type, while the co-pilot had recently been checked out and had only 15 hours on type, this being his third mission. Neither pilot was familiar with Toronto/LBPIA; the PIC had been there twice before, both times during daylight hours. The co-pilot had not previously been to Toronto/LBPIA. The crew had been on duty for approximately 12 hours and would be near their maximum allowed duty day of 14 hours upon arrival at their home base. Crew experience and duty and rest times calculated at the time of the occurrence were as follows:

Crew Flight and Duty Times	Captain	First Officer
Total Flight Time (hours) – Total / On Type	5270 / 360	7100 / 15
Flight Time Last 90 Days – Total / On Type	180 / 180	150 / 15
Flight Time Last 30 Days – Total / On Type	35 / 35	45 / 15
Flight Time Last 3 Days – Total / On Type	10 / 10	10 / 5
Flight Time Last 24 hours – Total / On Type	5 / 5	5/ 5
Hours On Duty Prior to Occurrence	12	12
Hours Off Duty Prior to Beginning Duty on Day of Occurrence	48	11
Hours Awake Prior to Occurrence	13	14
Duration of Last Sleep Period (in hours)	10	7

Departing Toronto/LBPIA, the PIC was at the controls and in the left seat. Prior to taxiing, the co-pilot received the air traffic control (ATC) clearance for the flight. At 2203, the co-pilot obtained a clearance to "taxi right on Juliett and hold short of Papa". The crew understood the clearance, correctly read it back, and made no request or gave any indication that they required progressive taxi instructions. Before reaching Taxiway Papa, ATC instructed N70AX to "taxi onto Foxtrot and hold short of Runway 05". The co-pilot read back the instruction correctly and proceeded to carry out the taxi-before-take-off checklist. The PIC had an aerodrome chart. He taxied the aeroplane while looking for the Runway 05 holding point and

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1 Central standard time (Universal Coordinated Time [UTC] minus six hours).

2 Except as noted above, all times are eastern standard time (UTC minus five hours).

responding to the co-pilot on checklist items. The PIC saw lights in the distance that he believed to be Runway 05 and crossed what appeared to him to be a taxiway but was, in fact, Runway 05.

Neither pilot was aware that the aircraft was entering Runway 05 and neither saw the Westwind C-FJOJ on the runway until after being advised by ATC. The co-pilot's head was down performing the checklist.

The Westwind C-FJOJ had been cleared to land on Runway 05. The crew saw the Learjet after it entered the runway and was illuminated by the Westwind's landing lights. The Westwind crew avoided it by using brakes and steering left to pass behind. It was a clear night with unrestricted visibility. There were no visual obstructions between N70AX and C-FJOJ during the latter's approach and landing.

The Toronto / LBPIA control tower at the time of the incident was staffed by 10 controllers, 7 active and 3 available. Their workload was considered light to moderate. The North Tower, South Tower, North Ground, and South Ground were all staffed. The following frequencies were in use:

Controller Position	Frequency (MHz)
North Tower	118.7
South Tower	118.35
North Ground	121.65
South Ground	121.9

The North Tower controller was controlling C-FJOJ on its approach. The runway was clear when the landing clearance was given and was still clear when C-FJOJ crossed the threshold.

In addition to N70AX, the North Ground controller was controlling four other aircraft, three taxiing and one under tow, which were on the east side of Runway 15L-33R, a different direction from N70AX as shown in Appendix A – Aircraft Positions. The North Ground controller communicated with three of these aircraft in the 60 seconds prior to the incursion and was monitoring the fourth as it was reaching its clearance limit. Within 10 seconds of the incursion, with C-FJOJ on the landing roll, the north ground controller scanned back to N70AX, which was travelling directly towards the control tower approximately one mile away.

It initially appeared to the north ground controller that N70AX would stop short of Runway 05 as instructed. The north tower controller expressed doubt and the north ground controller checked the airport surface detection equipment (ASDE) display and determined that N70AX was entering the runway. At about the same time, an aural conflict alarm sounded.

The following sequence of events was derived from ATC communications and ASDE recordings:

Time	N70AX	C-FJOJ
2206:20	• on taxiway Foxtrot • ~ 500 feet from Runway 05	• touching down • ~ 4000 feet from taxiway Foxtrot
2206:34	• crossing hold line short of Runway 05	• on landing roll, speed ~100 knots • ~ 1500 feet from taxiway Foxtrot
2206:43	• crossing edge of Runway 05 • speed ~16 knots	• on landing roll, speed ~64 knots • ~ 430 feet from taxiway Foxtrot
	Aural conflict alarm sounded in Tower	
2206:46	• fully onto Runway 05, approaching centreline of runway	• on landing roll, speed ~53 knots • ~ 300 feet from N70AX • pilot saw N70AX, braked and steered left to pass behind
2206:49	• crossing runway centreline	• on landing roll, speed ~26 knot • aligned to pass behind N70AX • ~ 60 feet between aircraft

Air traffic controllers have a duty to monitor the progress of aircraft proceeding in accordance with their control instructions. A NAV CANADA staff instruction [3] recognizes "full-time attentive flight monitoring and flight information services" as a primary goal that requires controllers to carry out several functions concurrently. This is explained as meaning that controllers must establish priorities within a multi-tasking environment and not allow their attention to be diverted by items having a much lower priority. [4] According to the NAV CANADA *Air Traffic Control Manual of Operations* (ATC MANOPS), controllers are to visually scan the manoeuvring area before issuing clearances or instructions and "to the extent possible, at other frequent intervals". For landing aircraft, the expectation is that the runway is clear of all obstacles by the time the landing aircraft crosses the runway threshold.

Toronto / LBPIA is equipped with ASDE that provides a real time display in the tower of aircraft and other traffic operating on airport manoeuvring areas. According to the ATC MANOPS, controllers should use ASDE to augment visual observation of traffic operating on the manoeuvring area by referring to ASDE at night, when visibility is restricted or, when in the controller's opinion, an operational advantage will be gained. The MANOPS notes that visual scanning is considered the primary technique. The MANOPS permits ASDE to be used to confirm compliance with control instructions.

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3 NAV CANADA Air Traffic Staff Instruction ATSI 2006-4, Full-Time Monitoring – A Question of Prioritizing Work

4 NAV CANADA Information Bulletin ATSI 9702, A Focus on Safety, 02 October 1997

ASDE incorporates a software subsystem known as runway incursion monitoring and conflict alerting system (RIMCAS) that tracks targets and provides warning of conflicts. The ASDE and RIMCAS systems were operating at the time of the occurrence. The systems were configured to monitor the arrival area of Runway 05 ahead of C-FJOJ while it was on final approach and landing, and to provide a visual alert to the controller in the event of a conflict within 30 seconds ahead of the landing aeroplane, and an aural warning alarm for a conflict within 9 seconds ahead. A conflict is defined under these conditions as the other aeroplane crossing the runway edge. RIMCAS-generated alerts and warnings are provided to ATC personnel only; they do not provide warnings directly to crews on board aircraft.

The current ASDE/RIMCAS system installed at Toronto is at its limits. Enhancements of the present system's warning capabilities are not possible due to the age of the software and operating system. An upgraded system, as installed at other NAV CANADA sites, is said to provide greater protection.

Taxiway Foxtrot was marked with a painted taxiway centreline and green taxiway centreline lights leading up to the intersection with Runway 05. The intersection was marked on each side of the taxiway with runway designation/location signs. The holding position, approximately 200 feet before the runway edge, was marked with two solid yellow lines and two dotted lines painted on a black background across the taxiway plus runway guard lights (two yellow lights that illuminate alternately at each edge of the taxiway adjacent to the hold line). The hold position is also provided with stop bars, which are flush-mounted red lights across the taxiway that are illuminated when the runway is in use in low-visibility conditions. The stop bars were not on at the time of the occurrence. These markings and lights comply with requirements as provided by an exemption to the *Canadian Aviation Regulations* (CARs). All of the lights and markings were in good condition, unobstructed, and (except for the stop bars) functioning.

Runway incursions have been recognized as a worldwide safety issue for some years. In July 1999, the Transport Canada (TC) National Civil Aviation Safety Committee (NCASC) formed a sub-committee on runway incursions (SCRI) to develop a national strategy. TC and NAV CANADA undertook parallel studies that resulted in more than 20 recommendations. [5] A team known as the runway incursion prevention action team (IPAT) was formed to oversee the implementation of the recommendations of the studies, which included, among other things, an awareness program, regulatory and procedural changes, and other measures to prevent incursions or to mitigate their effects. Preventive actions of note include:

- the standardization of runway and taxiway markings and signage;
- the standardization of terminology associated with ATC instructions to taxiing aircraft;

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[5] Transport Canada, National Civil Aviation Safety Committee, Sub-committee on Runway Incursions, Final Report, 14 September 2000, TP 13795E

- the requirement for explicit and specific clearance to cross all runways including those that are inactive; and

- the requirement for flight crews to read back taxi and hold short instructions.

In 2005, there was a decrease in the number of runway incursions and the IPAT was disbanded. A year later, the industry formed a Runway Safety and Incursion Prevention Panel (RSIPP) chaired by NAV CANADA to provide continued oversight of runway incursion prevention activities.

Canada and the U.S. have jointly developed an enhanced taxiway marking system intended to warn flight crews that they are approaching a runway holding position. The markings include enhanced taxiway centreline markings (yellow painted dashes on either side of the taxiway centreline leading to the holding position), extension of existing holding position surface-painted lines onto taxiway shoulders, and surface-painted holding position signs. These were implemented at major U.S. airports between 2005 and 2008. In September 2008, TC issued an exemption from *Aerodrome Standards and Recommended Practices* [6] permitting airport operators to adopt these markings.

Runway incursions have been on the U.S. National Transportation Safety Board (NTSB) "Most Wanted" list of aviation safety improvements continuously since 1990. One recommendation is to develop a means of providing immediate automatic indication of conflicts directly to flight crews in the cockpit for situations where there is not enough time to warn crews indirectly via air traffic control. The FAA has been developing a runway status light (RWSL) system to achieve this objective. Initial components of the system have been successfully tested, [7] indicating the feasibility of such a system. The FAA has begun to install it at some major airports while continuing the development of additional components of the system within the framework of the FAA's overall runway safety program. In Canada, the only automated runway incursion warning system is RIMCAS, which provides warnings only to air traffic controllers, not directly to the crews of aeroplanes. Neither TC nor NAV CANADA have recognized a need for such a capability and there are no plans to deploy a RWSL system or one with equivalent capability.

The International Civil Aviation Organization (ICAO) published a manual on runway incursions [8] in 2007. Its aim is to provide guidance to contracting states for the prevention of runway incursions. Canada was a participant in its development. The following recommendations from the ICAO manual pertain to the circumstances of this occurrence:

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6 Transport Canada, TP 312E, *Aerodrome Standards and Recommended Practices*, 4th edition, March 1993

7 Office of the Inspector General, U.S. Department of Transportation, *FAA's Implementation of Runway Status Lights,* Report number AV-2008-021, 14 January 2008

8 International Civil Aviation Organization, *Manual on the Prevention of Runway Incursions,* ICAO Doc. 9870, First Edition – 2007

- Conduct all communications associated with the operation of each runway (vehicles, crossing aircraft, etc.) on the same frequency as utilised for the take-off and landing of aircraft on that runway.

- Both pilots should be "Head up" for a continuous watch during aerodrome surface operations.

- Switch on stop bars to indicate that all traffic shall stop and switch off to indicate that traffic may proceed.

TC has not mandated these measures, nor is it required to because the ICAO document is advisory. However, beginning in February 2009, Toronto / LBPIA began to use stop bars in this manner to combat incursions by aeroplanes crossing Runway 06L/24R. Nine days later, there was an incursion while the stop bars were illuminated. In that instance, the crew failed to notice the stop bars or other runway hold markings, but they stopped before entering the runway itself because they were aware that they were approaching the runway and identified it through other means.

The ICAO identifies four levels of severity. Applying the ICAO definitions would categorize this occurrence as severity "A", which is defined as a serious incident in which a collision is narrowly avoided. This is the most serious level on the ICAO scale.

An International Air Transport Association (IATA) study [9] into runway incursion trends identified the following factors that pertain to this occurrence:

- Pilot deviations, defined as actions by a pilot that result in violation of a regulation, account for 55 per cent of runway incursions.

- Over half of runway incursions occurred while an aeroplane was taxiing out.

- Management of workload during taxiing frequently resulted in only one crew member monitoring the taxi route and clearances. One of the main distractions was identified as before-take-off checklists.

- Where the incursion was a failure to hold short, aerodrome markings, night, and poor visibility were contributing factors.

- Fatigue (for example, being on the third or fourth leg of the day) and operational pressure were cited as common contributing factors.

Runway incursions are reportable events under TSB regulations if they result in an accident, a collision, or the risk of a collision involving an aeroplane having a maximum certified take-off weight of greater than 5700 kg (for a helicopter, greater than 2250 kg). During the past 10 years, there have been 14 investigations into occurrences involving a runway incursion; 3 of these occurrences are still under investigation.

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9 IATA, Safety Trend Evaluation, Analysis and Data Exchange – Runway Incursions, 2008

The completed investigations indicated that five occurrences involved pilot deviations, only one of which was a failure to hold short of a runway, and six involved inappropriate ATC instructions. Other contributing factors were essentially consistent with factors that have been identified in other studies into runway incursions and included darkness or poor visibility, and miscommunication. Although human factors were involved in all, no single system deficiency or cause was discernible, nor was any single preventive strategy identified, apart from education and awareness initiatives.

The RIMCAS was not available as a defence in any of the 11 occurrences previously investigated by the TSB. However, a finding in one occurrence indicated that without an automated system to provide a warning directly to flight crews in the cockpit, the RIMCAS system may not provide sufficient warning time to prevent an accident. Another report acknowledged the physiological limitations of human vision in the effectiveness of visual scanning techniques by both pilots and controllers.

Because the majority of runway incursions are not reportable to the TSB, TC records were reviewed for runway incursions in Canada. There were 3831 incursions nationwide in a 10-year period from 1999 to 2008, 183 of which occurred at Toronto / LBPIA. Trends are presented in Appendix B - Runway Incursion History in Canada. Both nationwide and at Toronto / LBPIA, runway incursion reports decreased in the period from 2002 to 2005; they have since increased. These trends are closely related to the number of air traffic movements. Approximately one-third of the Toronto / LBPIA incursions occurred at night.

Analysis

This incident occurred when the pilot of N70AX misidentified Runway 05 as being in the distance and continued to taxi into the path of a landing aeroplane despite the following passive measures intended to defend against crew deviations:

- airfield markings and signage complied with relevant standards;
- signs and markings were unobstructed and visibility was good; and
- ATC instructions complied with relevant standards, were clearly understood, and were read back correctly.

The crew did not correctly perceive their location on the airfield. None of the indicators of the hold-short point were prominent enough to attract their attention and overcome their perception that they were proceeding correctly. Potential factors contributing to their reduced level of awareness are familiar from previous studies:

- the incursion occurred while taxiing out;
- only one crew member was monitoring the taxi route and compliance with the instruction;
- distraction by the before-take-off checklists;

- night lighting conditions;

- fatigue associated with the third leg of the day at the 12-hour point of the crew duty day; and

- operational pressure (self-imposed because the crew would be at the limit of their crew day by the time they reached home base).

Additional indications of the holding point, such as illuminated stop bars or enhanced taxiway markings system, could be provided; however, it is uncertain if these would overcome the pilot's misconception of his position. It is noteworthy that when Toronto / LBPIA began to use stop bars to additionally denote the holding point at another runway, it was only a very short time before this defence failed under circumstances in which a crew was actively looking for indications of the runway.

It is also inconclusive whether putting the taxiing aeroplane on the same frequency as aircraft landing and taking off would have had an effect because this measure is intended to avoid coordination errors between controllers. In this instance, it would depend on the timing of clearances and frequency changes, and could induce other risks when airport controller workload is factored in.

Monitoring by air traffic controllers provides another level of defence against incursions. The ground controller was monitoring five aircraft at the time, none of which could be viewed as being of "much lower priority". Four of these aircraft were to the east side of the field; only N70AX was northwest of the tower, resulting in the controller having to scan a large arc. When the incursion took place, the controller had looked back towards N70AX, but the impending incursion was not obvious due to relative movement being directly towards the tower and therefore not easily discernable to the human eye, especially at night. The controller attempted to use the ASDE display for additional certainty, but the event unfolded too quickly and he did not detect that N70AX had passed the hold line and was proceeding onto the runway until the aural warning sounded after the incursion had occurred.

The RIMCAS system is intended to provide an additional level of defence. The aural warning provided insufficient time for controllers to instruct either aircraft and therefore would not have averted a potential collision. In this occurrence, even with low-visibility settings, RIMCAS would have provided a warning only nine seconds before the Learjet entered the runway. Whether configured for good or poor visibility, the RIMCAS warning comes only after an incursion has taken place. Therefore, as presently configured, RIMCAS can only assist in mitigating the consequences by defending against the collision that might follow. Averting a collision after a RIMCAS warning is highly reliant on the controller providing appropriate instructions to the flight crews in time for them to take action. This occurrence demonstrates that in the most critical situations, the shortness of time and swiftness of events can defeat this defence and the controller will have insufficient time to avert the collision. To be effective, the RIMCAS would have to provide a warning in sufficient time before the aircraft reaches a holding point to allow the controller to intervene and prevent an incursion.

The number of runway incursions fell between years 2002 and 2005 during a period of decreasing traffic levels. Since then, it has returned to previous levels despite the defence measures that were undertaken. Also, the passive measures intended to reduce pilot deviations related to entering runways at taxiway hold points may reduce the likelihood of these types of incursion, but can not entirely eliminate them. The residual risk remains high due to the potential for catastrophic consequences in the event of a collision at high speed. The greatest likelihood of a high-speed encounter is at mid-points on runways where an aeroplane taking off is reaching its take-off speed or a landing aeroplane has not yet decelerated to taxi speed.

Runway incursions occur for many reasons including pilot deviations, controller deviations, vehicle operator deviations, and pedestrian deviations. ASDE / RIMCAS remains the only automated device that independently detects incursions, but sufficiency of warning and reaction time limits its effectiveness. Moreover, the current ASDE / RIMCAS system installed at Toronto / LBPIA can not be enhanced to provide the greater level of protection that is said to be installed at other NAV CANADA sites.

Findings as to Causes and Contributing Factors

1. Both crew members of Learjet N70AX were unfamiliar with the Toronto / Lester B. Pearson International Airport and did not correctly perceive their position on the field. As a result, they did not hold short of the runway as instructed by air traffic control (ATC) and unintentionally proceeded onto the runway into the path of a landing aeroplane.

2. The co-pilot did not assist in monitoring the taxi route or compliance with instructions because he was carrying out checks while the pilot-in-command (PIC) taxied the aircraft.

Findings as to Risk

1. A crew's alertness may be reduced by operational pressures and fatigue associated with a long duty day and multi-leg scheduling.

2. The runway incursion and monitoring and conflict alerting system (RIMCAS) does not provide sufficient time to prevent incursions, nor does it provide sufficient warning to allow air traffic controllers to avert a collision.

3. There is currently no automated runway incursion warning system to warn flight crews directly of impending incursions or conflicts.

Safety Action

Action Taken

The aircraft has been fitted with a Garmin 696 system that depicts its location on the airfield. It is under trial to be used in conjunction with aerodrome manoeuvring charts to reduce the risk of inaccurate navigation.

Safety Concerns

Two Heads Up

The practice of performing non-essential checklists while taxiing for departure is a common one. The practice, as demonstrated in this occurrence, results in only one pilot monitoring the taxi route and the aircraft's compliance with traffic instructions. The Board is concerned that, unless explicitly curtailed, completion of non-essential checklists during taxiing in order to expedite take-off will continue to remove a primary defence against potential runway incursions.

ASDE/RIMCAS at Toronto / Lester B. Pearson International Airport

It is reported that the existing airport surface detection equipment / runway incursion and monitoring and conflict alerting system (ASDE / RIMCAS) at Toronto / Lester B. Pearson International Airport is at its limits and can not be enhanced due to the type and age of its software. NAV CANADA is reviewing its possible replacement. In the meantime, the Board is concerned that Canada's busiest commercial airport is apparently operating with an ASDE / RIMCAS that does not provide the same level of protection as that available at other airports in Canada.

Direct Warnings of Runway Incursions to Flight Crews

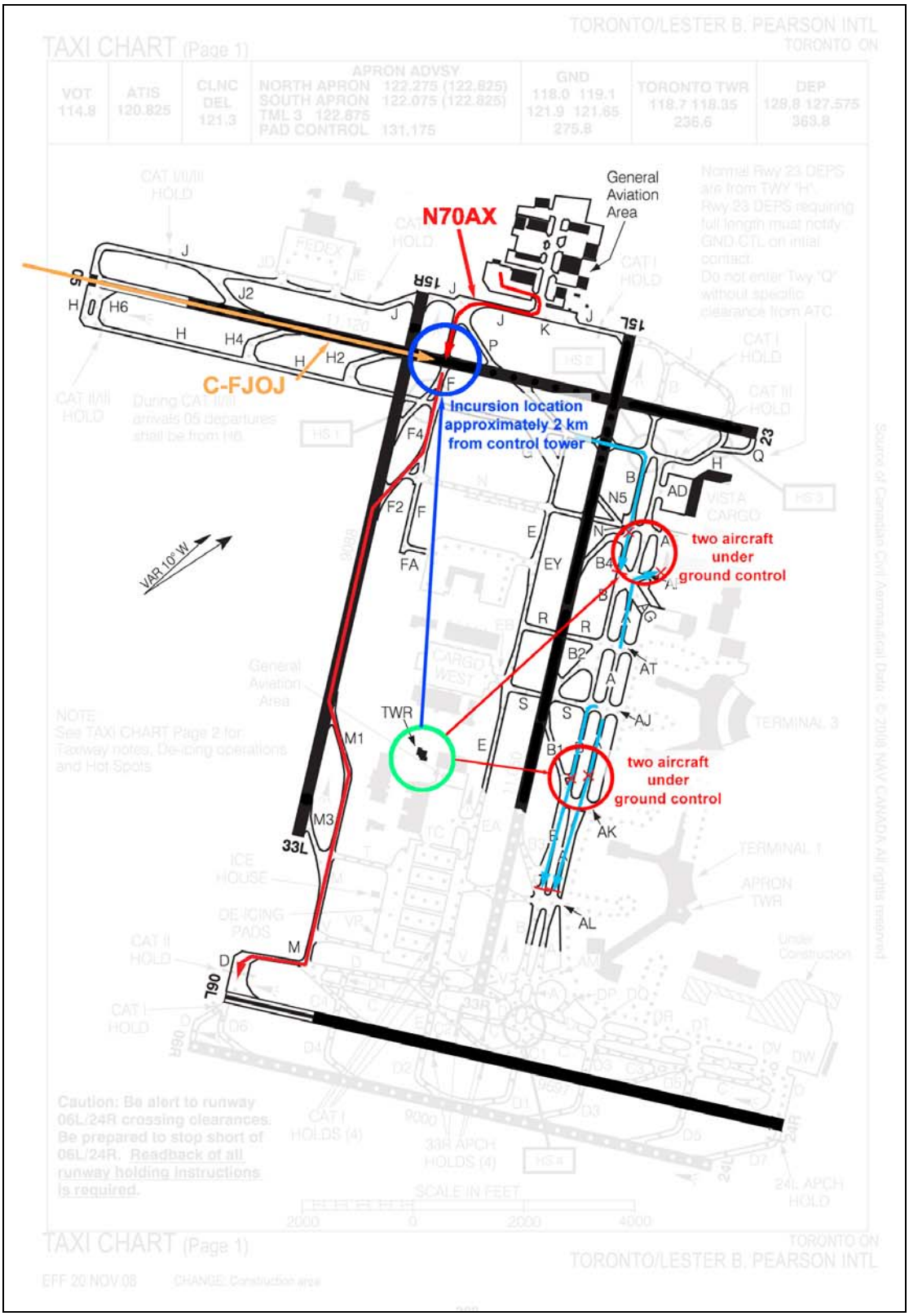
It is, however, unclear whether even an improved ASDE / RIMCAS can significantly reduce the risk of runway incursions and their potentially catastrophic outcomes. The improved system will continue to rely on the interpretation of warnings by controllers and their subsequent radio communication with aircraft and vehicles. The provision of warnings directly to flight crews provided the impetus for the current testing and introduction of the runway status light (RWSL) system by the Federal Aviation Administration at some airports in the United States.

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

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 03 November 2009.

Visit the Transportation Safety Board's Web site (www.bst-tsb.gc.ca) for information about the Transportation Safety Board and its products and services. There you will also find links to other safety organizations and related sites.

Appendix A – Aircraft Positions



Appendix B – Runway Incursion History in Canada

The following data was extracted from Transport Canada's civil aviation daily occurrence reporting system (CADORS) database based on the International Civil Aviation Organization (ICAO) definition of a runway incursion:

> Any occurrence at an aerodrome involving the incorrect presence of an aircraft, vehicle, or person on the protected area of a surface designated for the landing and take-off of aircraft.

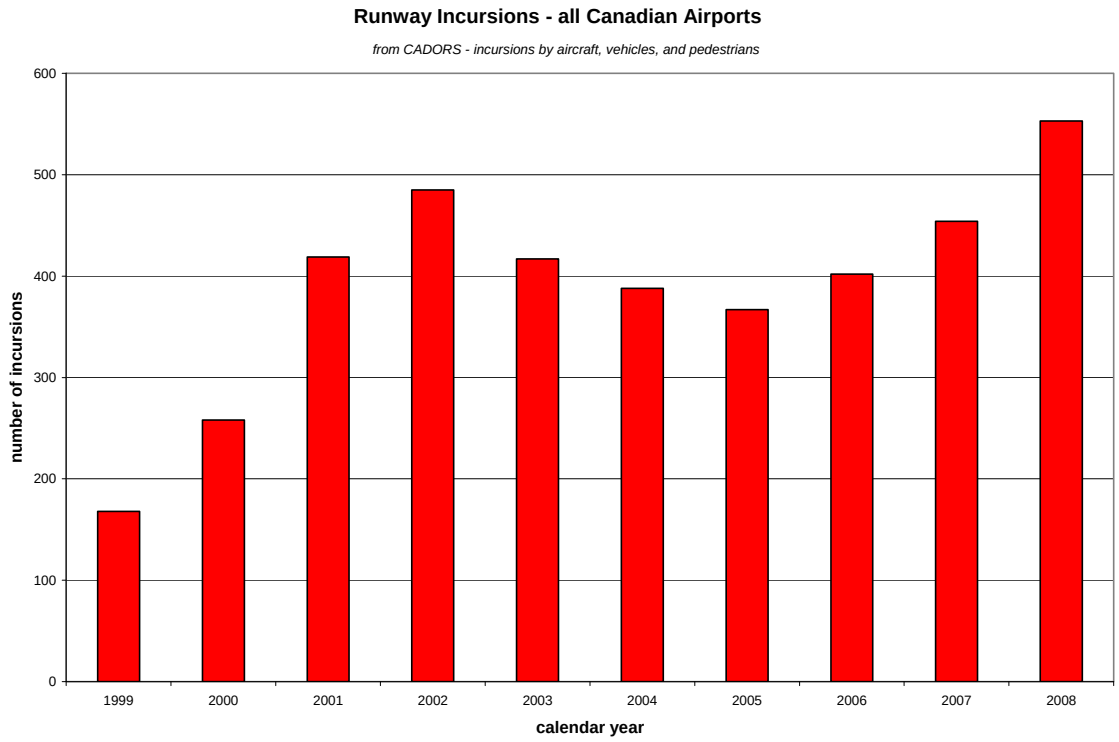


Figure B-1.
Runway Incursions – All Canadian Airports

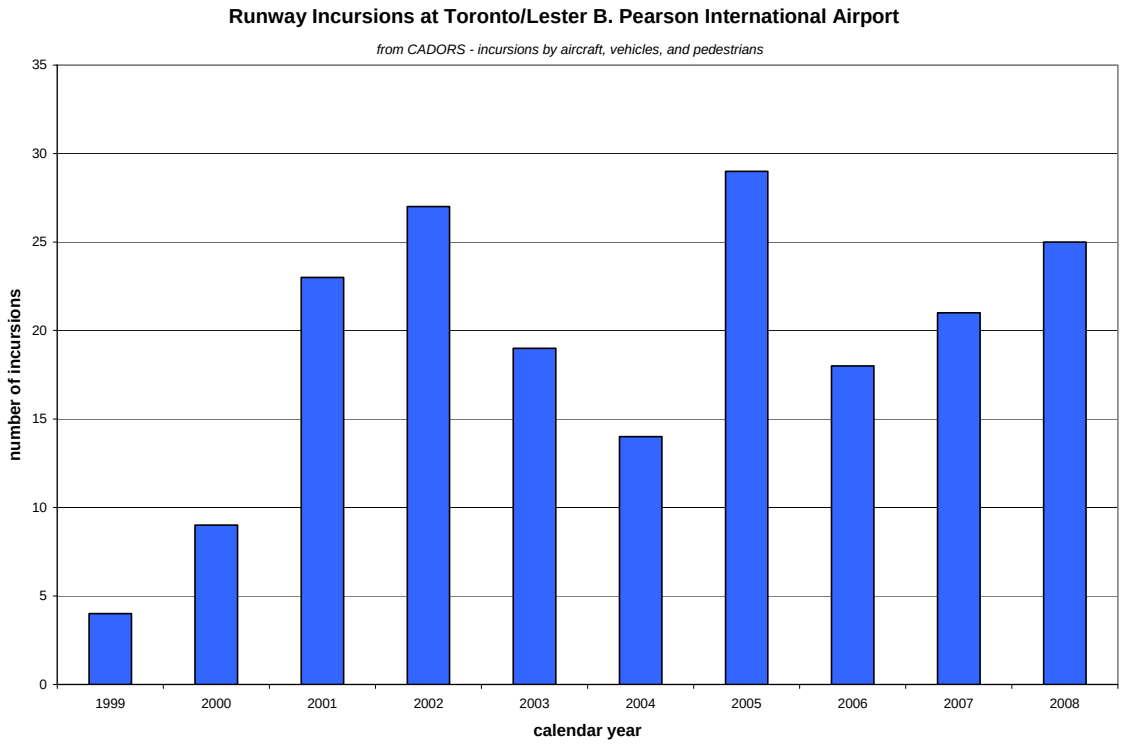


Figure B-2.
Runway Incursions – Toronto/Lester B. Pearson Airport