NAV CANADA

Runway Incursion Study

at NAV CANADA ATS facilities

Final Report

February, 2001

Table of contents

1.0 Introduction

The issue of runway incursions at Canadian airports was raised at the National Civil Aviation Safety Committee meeting in Ottawa on July 13, 1999. As a direct result of the concerns expressed by Safety officials during this meeting, the NAV CANADA Director of Air Traffic Services (DAT) requested that a plan be developed to study and address the problem of runway incursions.

The DAT approved the terms of reference for this study in October 1999. The Airport/Terminal Operations section of the Airspace and Procedures Branch in Ottawa Head Office assumed responsibility for the execution of the study. John Cantin, Regional Airport Specialist, Western Region was appointed to oversee the project and reported directly to the manager of Airport/Terminal operations in Head Office. Co-incidental to the development and implementation of this plan by NAV CANADA was the formation of the Transport Canada "Sub-Committee on Runway Incursions" (SCRI).

1.1 Plan Objectives

The following broad objectives were approved by the DAT:

- Improve data collection and analysis.

- Conduct extensive reviews at the site level.

- Review and revise ATS procedures, where required.

- Seek improvements in controller and FSS communications.

- Ascertain human resource needs.

- Improve communications in the aviation community.

- Develop awareness initiatives for use internally by NAV CANADA.

2.0 METHODOLOGY

To achieve the goals as set out in the Terms of Reference, the project chair chose the following methodology:

- Conduct a thorough literature review of worldwide activities related to runway incursions.
Determine sites to visit and arrange for discussions with local stakeholders.
- Interview company staff, review local directives and procedures, assess effectiveness of existing alerting devices, and observe operations in ATS units at selected sites.
- Conduct "Safety Roundtable" meetings to include stakeholders such as air carriers, local airport authorities, representative pilot groups, and NAV CANADA personnel.
- Compile and prepare summary reports for each site visited.
- Convene a panel of aviation experts to review the data.
- Include panel recommendations in the final report to the Director, Air Traffic Services. It was determined that the panel would discuss the results of the site visit findings. The panel of experts would consist of representatives from NAV CANADA Airspace & Procedures, NAV CANADA Office of Safety & Quality Management, NAV CANADA site management, NAV CANADA operations, Air Canada operations, Calgary and Winnipeg Airport Authorities, Transport Canada safety programs, Flying Colors flight training school, Department of National Defense(DND) ATC Winnipeg, Transportation Safety Board (TSB), and the Air Traffic Specialists Association of Canada. Many of the recommendations found at the end of this document are a result of the deliberations by this panel.
- Provide the Director with study findings and recommendations.

The study into runway incursions began with the approval of the terms of reference in October of 1999 and continued until the panel of experts meeting held in Winnipeg between June 27-29, 2000. The broad scope of the project's action plan warranted the collection of information and data from many sources including but not limited to airport authorities, ANS customers, and ANS providers at NAV CANADA serviced airports with both high and low incidences of incursion reports.

Transport Canada's National Civil Aviation Safety Committee established a Sub-Committee on Runway Incursions (SCRI) at approximately the same time as the NAV CANADA effort. The chairperson of the NAV CANADA incursion study participated on the Transport Canada committee and as a result, considerable collaboration between Transport Canada and NAV CANADA occurred during the execution of the plan. Many of the recommendations contained in this report are identical in nature to the recommendations in the SCRI report released on September 20, 2000.

2.1 Terms of Reference

The Terms of Reference approved by the DAT listed seven main points:

2.1.1 Improve data collection and analysis.
Runway Incursions are being reported almost daily in the company's Aviation Occurrence Reporting (AOR) database yet, until 1997, no agency within the company isolated or summarized incursion incidents and accurate records as to their extent or cause were not kept.

The NAV CANADA Office of Safety and Quality Management (OSQM) began a manual extraction of information concerning runway incursions from the AOR database in early 1997 and created the first "Runway Incursion" database. Initial data drawn from this new database was published in the November 1998 issue of "Safety Insight". Other database sources, such as the Transport Canada Civil Aviation Occurrence Reporting System (CADORS) were also used.

To facilitate the runway incursion study, the responsibility for the daily extraction of incursion data from these databases to the runway incursion database was reassigned to the incursion study chair. Locally filed AORs were compared to the national AOR database during this collection and analysis phase.

2.1.2 Conduct extensive reviews at the site level.
The collection of operational data from various airports within the study time-frame was determined to be the best method of providing the expert panel with an overall view of the incursion problem in Canada. Site visits to airports with different runway configurations and aviation activities were conducted.

Managers at selected NAV CANADA sites were requested to invite local stakeholders to participate in safety roundtable sessions. Those who attended these roundtables included local airport authorities (airside operations), NAV CANADA staff representing all disciplines, and local operators. At major sites, airline operators were also invited.

Safety roundtables were conducted during the following site visits:

Toronto City Centre - January 10 & 11, 2000	Ottawa - March 20, 2000
Hamilton - January 12 & 13, 2000	Vancouver - March 21 & 22, 2000
Quebec City - January 18 & 19, 2000	Abbotsford - March 23 & 24, 2000
Montreal Dorval - January 20 & 21, 2000	Nanaimo - March 27 & 28, 2000
Moncton - January 24 & 25, 2000	Calgary - April 2 & 3, 2000
Halifax - January 26 & 27, 2000	Medicine Hat - April 5 & 6, 2000
Winnipeg - February 14 & 15, 2000	Edmonton - April 10 & 11, 2000
Thompson - February 16 & 17, 2000	Toronto Pearson - May 15, 2000
Thunder Bay - February 18 & 21, 2000	

Meetings consisted of a slide show presentation by the incursion study chair, followed by an information and data session on the national status of runway incursions. A statistical

breakdown of incursions by site, including type of event and type of aircraft was also conducted. A period of open dialogue followed the slide show with discussions focusing on the stakeholders' perspective of the problem including communications, signs & markings and groundside operations.

2.1.3 Review and revise procedures, where required.
Suggestions and comments were collected from NAV CANADA operational staff during site visits. This input was reviewed during the expert panel's discussions on existing procedures. The role and responsibilities of the site supervisors were discussed to determine the effectiveness of stand back supervision.

Of particular interest was the type and usage of runway occupancy devices as well as the use of headsets by ATS staff.

2.1.4 Seek improvements in controller and FSS communications.
The phraseology training sessions that form part of the annual currency training for controllers and specialists are intended to improve their communication techniques (clarity, delivery, speech rates, and enunciation). The use of non-standard phraseology was identified in some fact-finding board (FFB) reports as a contributing factor during some operational incidents. The panel discussed the relationship between communications and runway incursions.

2.1.5 To ascertain human resource needs.
Methods of currency training for employees (NAV CANADA and others) were reviewed during the study and discussed by the panel.

2.1.6 To improve communications in the aviation community.
The opinions gathered from stakeholders during site visits can assist Transport Canada, NAV CANADA and Airport Authorities in developing and conducting campaigns to heighten awareness within the aviation community and provide directed training to mitigate causal factors that lead to runway incursions. This approach would encourage the promotion of pilot and airport authority involvement in runway incursion awareness programs at the site level.

2.1.7 To develop awareness initiatives for use by NAV CANADA.

The severity of the incursion issue was first brought to the attention of operational personnel through a "Squawk 7700" safety bulletin in 1997. The OSQM published "Safety Insight" newsletters in 1998 and 1999 and an additional Squawk 7700 safety bulletin was issued in early 2000 to provide staff with an incursion alert. The panel also addressed additional methods of developing awareness.

2.2 Runway Incursion Definition

The original definition of a "Runway Incursion " was: *"the unplanned or unauthorized presence of an aircraft or vehicle on or near the active runway"*. This definition did not include any reference to incursions by pedestrians. The word "pedestrian" was added to the definition before the site visits. During the site visit in Montreal, local ATC participants presented strong rationale to record the unauthorized infringement of inactive runways as well. Subsequently, the definition was changed to *"the unplanned or unauthorized presence of an aircraft, vehicle, or person on or near a <u>serviceable runway</u>"*. This revised definition was adopted by the SCRI as well.

- Recommendation # 1

  The expert panel reviewed the revised definition and determined it was too limiting and narrow in scope. The expert panel recommended the following change to the definition to better capture incursion events.

  "*Any occurrence at an airport involving the unauthorized or unplanned presence of an aircraft, vehicle, or person on the protected area of a surface designated for aircraft landings and departures".*

The Federal Aviation Administration (FAA) in the United States has taken a different approach to the classification of runway incursions. By using a hazard-based incursion definition, suspected events are classified only if there is <u>a collision hazard or loss of separation</u> at a controlled airport. As a result of incursions being recorded only at controlled airports, a number of incursion related accidents in the US at non-towered airports are not included in their totals.

By contrast, the <u>event-based</u> definition adopted by NAV CANADA, incorporates all violations of the Canadian Aviation Regulation (CAR) requirement to remain 200 ft. from the edge of a runway (or as indicated by the taxi "hold" markings), as well as the unauthorized entry onto any surface used for landing an aircraft at both controlled and uncontrolled airports. With this definition, the recording of incursions and violations of the 200 ft. safety barrier or hold line provides, NAV CANADA with the capability to better determine risk at any airport.

2.3 Severity Categories

(The following is from the SCRI report)

"Severity and frequency are the two components necessary to calculate risk. Whereas the frequency of occurrence can be derived directly from the occurrence data, the severity of each occurrence must be inferred by assessing the circumstances surrounding the event. To assist with this process, the SCRI developed five categories, organized to represent the failure of various levels of defense, for describing the severity of a runway incursion. The severity categories are:

a. **Negligible** - the occurrence would not have caused a collision between aircraft or vehicles. No intervention required to keep the runway clear. *(Example: An aircraft or vehicle was near (within 200 feet) but not on a serviceable runway and stopped short of the runway surface without intervention).*
b. **Low** - the occurrence was unlikely to result in a collision between aircraft or vehicles. ATC or pilot intervention was required to keep the runway clear. *(Example: A vehicle or aircraft was near (within 200 feet) but not on a serviceable runway and stopped short of the runway surface when contacted by ATC).*
c. **Medium** - the occurrence could have resulted in a collision between aircraft or vehicles. A vehicle or aircraft was on a serviceable runway without authorization or was cleared onto (or across) a serviceable runway by mistake. *(Example: An aircraft crosses a serviceable runway without clearance).*
d. **High** - the occurrence could have resulted in a collision between aircraft or vehicles. A vehicle or aircraft was on a serviceable runway without authorization or cleared by mistake and a **clear risk of collision** existed. Normally requires ATC intervention to correct. *(Example: Two aircraft take off from the same runway at the same time).*
e. **Extreme** - the occurrence would have resulted in a collision between vehicles and/or aircraft and was prevented only by **last minute evasive action** by the aircrew and/or vehicle operator(s). *(Example: A pilot rejects a take-off to avoid a collision with a vehicle or another aircraft)"*
- Recommendation # 2
  The expert panel suggested the adoption of the same severity factors as proposed by the Transport Canada SCRI. These severity factors range from Negligible to Extreme.

2.4 Classification of Runway Incursions

To be consistent with other agencies researching the incursion problem, NAV CANADA decided early in the investigation process to adopt a similar system to the FAA classification of runway incursions. The classifications are:

2.4.1 Operating Irregularity (OI) – A situation which occurs when air traffic services are being provided and when a preliminary investigation indicates that safety may have been jeopardized, less than minimum separation may have existed, or both (ATC MANOPS).

2.4.2 Pilot Deviation (PD) - action of a pilot that results in non-compliance with an ATC instruction/clearance or a violation of a Canadian Aviation Regulation.

2.4.3 Vehicle/Pedestrian Deviation – a situation that occurs when a vehicle operator, a non-pilot operator of an aircraft, or a pedestrian proceeds without authorization onto the protected area of a surface designated for landing or taking-off. This classification includes security breaches but excludes animals.

3.0 Findings and recommendations

3.1 Data Collection

Data collection begins with the filing of a report of an alleged incursion with the parent ACC by the controller or specialist at the site level. The ACC Shift Manager enters the information into the NAV CANADA Aviation Occurrence Report (AOR) master database. The AOR database is sent automatically to Transport Canada and the events are entered into the Transport Canada Civil Aviation Daily Occurrence Reporting System (CADORS). Transport Canada then assigns an Office of Primary Interest (OPI) and updates the report on a regular basis.

NAV CANADA also checks the AOR database on a daily basis. All incursion data is extracted, examined, and a subjective determination made as to whether an incursion, according to the official definition has occurred. This information is then entered into a separate "Runway Incursion" database. The CADORS database is also checked on a weekly basis for incursion events not reported by NAV CANADA. A Transport Canada safety analyst also extracts incursion information from the CADORS file for inclusion into a second, separate incursion database. The Transport Canada and NAV CANADA databases are occasionally reconciled to ensure the reported incursion numbers are similar. This process is time consuming and requires a dedicated resource. Due to the subjective determination of an incursion, occasional differences of opinion between NAV CANADA and Transport Canada as to whether an event is in fact a runway incursion have surfaced. The databases are accurate in number of events to ±5%.

- Recommendation # 3
  Improve the existing Runway Incursion database and the AOR classification criteria to lessen the amount of time required to review occurrence reports and extract the pertinent information.

3.2 Analysis

3.2.1 Information collected during the site reviews indicates that occasional selective filtering occurred at some ACCs. The original reports, as filed by the site, were compared to the AOR of the event. The change in wording in one case changed the original runway incursion event to a taxiway incursion event. In two other cases, the site report was not entered into the AOR database. There was no way of determining why these reports were not entered. Direction has been given to ACCs to ensure proper recording of incursion events.

3.2.2 The data from the NAV CANADA database, site visits and other sources, has shown that the number of incursions tends to increase in the spring and summer, a direct correlation exists with traffic volume and that most incursions occur during daylight VFR conditions. Fortunately, this provides the opportunity for either the pilot or controller to detect the impending incursion and take appropriate action.

3.2.3 Studies have shown that the highest accident potential is during IFR weather conditions or during periods of darkness.

3.2.4 The combining of all data from controlled and uncontrolled airports provides a partial measure of occurrence accuracy. FSS are not permitted to issue instructions to "HOLD" or "HOLD SHORT" to an aircraft while controllers can.

3.2.5 Local authorities and stakeholders expressed a desire to have password protected read-only access to the incursion database during site visits. The project chair and others describe a need to redesign the NAV CANADA runway incursion database to include all required fields (uncontrolled/controlled, severity factor). It is suggested that the office of Safety & Service Design or the Office of Safety & Quality Management should control database design and input.

- Recommendation # 4

   The expert panel determined that incursion data should continue to be captured from controlled and uncontrolled sites, but addressed separately. The panel suggested that NAV CANADA management redesign the database to determine it's required elements and maintenance as well as methods of sharing the information with outside agencies.

3.2.6 Pilot deviations represent the highest number of reported incursion events, however, there is very little information collected from the pilots to enable NAV CANADA to analyze performance or determine procedural deficiencies.

3.2.6 Site reviews have determined that ATS personnel at some sites were not sure what constituted a runway incursion and were not reporting the events. Subsequently, a "Squawk 7700" Safety Bulletin was issued in early Summer 2000 to provide operational staff with a definition and other incursion information. This may account for some of the increase in reported runway incursions.

- Recommendation # 5

The panel suggested that NAV CANADA establish a focal point (team) within the company to continue efforts to address the runway incursion problem, develop a formal presentation and continue to provide an awareness program to all NAV CANADA employees during site visits.

The visits would also deal with pertinent issues at the site and should include other operational subjects such as Mandatory Frequency (MF) and Simultaneous Intersecting Runway Operations(SIRO) issues. NAV CANADA could chair bi-annual meetings at all major airports to discuss mutual problems with the Canadian Airports Council, Canadian Owners and Pilot's Association, and all levels of carriers. Comments from the attendees at all sites were positive to this initiative.

- Recommendation # 6
  The involvement of all facets of airport operations was viewed by the panel as a necessary step when discussing mutual problems.

3.2.7 Limited "Human Factors" information is being captured within NAV CANADA through the fact-finding process. Human factors information collected both from ATS personnel and from pilots would provide better insight into the possible causes of runway incursions. No recommendation was made with respect to human factors.

3.2.8 Some runway incursions are not being reported by other agencies, suggesting that local counseling of pilots and vehicle operators as to the reporting requirements is required. Information gathered from the site visits indicated that some local authorities determine whether an event jeopardizes safety and deal with it accordingly. One site reported a concern about the possible punitive actions against a vehicle operator and chose to deal with an incursion problem locally as well as not reporting it. (Some benefits may result from a non-punitive reporting system for pilots and vehicle operators). Other reasons given for non-reporting included overtime costs for position relief and the associated paper work. Aircraft or vehicles that encroached past the 200' hold line but did not enter the runway proper, were considered non-events by some participants.

- Recommendation # 7

  The panel suggested that airport authorities meet with Transport Canada to discuss an awareness program for airport vehicle operators.

3.3 The OI and ATS Operational Errors

The research that occurred during this project included a review of incursion-related incident reports. Some of the causes of Operating Irregularities by operational ATS staff, as determined by the NAV CANADA 's fact-finding (FFB) process are listed below:

3.3.1 Forgetfulness is the most common cause of runway incursions by controllers. A study of FFB reports indicates that controllers occasionally forget aircraft or vehicles on a runway and clear other aircraft for an operation on the same runway.

In the mid-80s, ATC managers were directed to install an electro-mechanical or mechanical system to indicate the occupancy status of all runways. As a result, many varied alerting devices and memory aids were developed and are in place across the country today.

Although most operating ATC and FSS positions have a procedure or device to display the runway occupancy status, investigation into OIs has shown that operational personnel are still forgetting that aircraft or vehicles are on the active runway. In some instances, it was reported that the procedures or devices were not always activated when required. In other instances, FFB reports indicate that the device had been activated but the controller ignored the warning provided by the device and continued with normal operations on the runway. Comments from field personnel indicated that the effectiveness of the runway occupancy alerting devices appears to diminish with time and that the effectiveness and usefulness of each should be re-evaluated to determine the merit of each.
The site visits confirmed the lack of a standard device or system for displaying the runway occupancy status.

- Recommendation # 8

    The panel suggested that a decision be made by NAV CANADA on the requirement for a standard national incursion warning system.

3.3.2 Distractions - The fact-finding reports indicate that controllers and specialists have been distracted by extraneous conversations occurring in the operations area. The reports indicate that the problems appear to lessen when headsets are utilised.
Other contributing factors to the problem of distraction was the presence of non-operational reading material, radios, cell phones, televisions and personal phone calls. The recommendations from these reports suggest a need to ensure that distractions are kept at a minimum. This responsibility falls to site managers and supervisors.

- Recommendation # 9

    It was suggested that site managers and supervisors be reminded of their responsibilities regarding functional goal #1: Full-time attentive flight monitoring.

3.3.3 Introduction of new technology – Discussions with NAV CANADA personnel and from the expert panel have indicated that controllers invariably worked "heads down" at critical operational moments during the period when tower controllers were coping with the introduction of new technology such as EXCDS. Findings indicate that as familiarity and competency with the new technology increased, the problem appeared to be less evident. No recommendation was made.

3.3.4 Phraseology - An analysis of transcripts from FFB records and from Briefs for Counsel revealed that non-standard or inopportune phraseology continues to be a contributing factor in a number of ATS occurrences. Several pilots who attended the site meetings stated a number of ATC taxi instructions are received at inconvenient, high workload times during landing and rollout phase. Rapid rate of speech by the controller was also cited as a problem when the workload is high and/or the frequency is congested.

- Recommendation # 10
  The panel suggested that NAV CANADA authorities conduct a more rigorous monitoring of ATS phraseology and procedures, including random tape checks and real time on-site monitoring.

 3.3.5 Readback/hearback – Some FFB reports have indicated that controllers miss incorrect readback of instructions. This would suggest a problem with attentiveness (mental wandering) or distractions.

- Recommendation # 11
  The need to continue emphasising situational awareness and professionalism at refresher training was identified. (See recommendation 13)

3.4 Pilot Deviations (PD)

An analysis of the incursion statistics indicate that most "Pilot Deviations" (PD) involve light aircraft and that most incursions by these aircraft occur in VFR weather conditions and during daytime periods. Statistics from other sources indicate that most of the runway incursion-related accidents (world-wide) have occurred at night or in poor visibility conditions and involved airline transports or turbine-powered business aircraft flown by professional pilots. This incursion/accident relationship would tend to suggest the success of the see-and-avoid principle during day VFR operations and perhaps the importance of electronic monitoring aids during operations at night or in periods of reduced visibility.

3.4.1 Data Collection - Depending on the type of event and the size of aircraft, certain pilots are interviewed formally or informally by the Transportation Safety Board, Transport Canada enforcement, and on occasion, the NAV CANADA site manager. There is currently no mechanism in place to determine factors that contribute to pilot deviations (PD). Information relating to the number of pilots on board, their qualification level, activities at the time of occurrence or pilot comments as to what they felt were causal factors is not captured on a consistent basis. This lack of data makes it impossible to reach any valid conclusions regarding pilot deviations.

3.4.2 Ground Operations – Pilots who attended the safety roundtable sessions stated that not enough emphasis is placed on ground operations during initial pilot training. Airline pilots on the panel were reluctant to admit they were unsure of their position during ground taxi operations. Several business jet pilots professed to advising ATC of their unfamiliarity with an airport and were provided with "progressive taxi" instructions by ATC. No recommendation was forwarded.

3.4.3 Signage and markings - This topic created the most discussion and raised the most concerns at all the roundtable sessions (See also 3.8). Surprisingly, discussions at these meetings determined that there is no common signage and markings standard in Canada. Aerodromes only have to comply with the version of the Transport Canada document that was in effect during initial airport certification. Transport Canada is currently reviewing and will be rewriting TP 312, Aerodrome Standards and Recommended Practices, which includes signage and marking standards.
In the United States, NASA is evaluating the use of 3-D hold line painting system (see below). A new technology using laser markings is also being marketed and will provide pilots with hold line alerts.

NASA 3-D Hold Line Markings

The installation of "rumble" strips was discussed at some of the site meetings. These are grooves cut into the taxiway surface to alert pilots of approaching hold lines. There was no support from either the pilots or airport authorities on this issue as it was felt the strips would create too many problems (accumulation of ice or contaminant, damage to aircraft gear). No recommendation was offered.

3.4.4 Cockpit management – The pilots on the panel indicated that the new glass cockpit found in many of today's newer aircraft introduced the same "head down" problem being encountered by ATS personnel. Although the airlines continue to emphasise the need for vigilance during ground operations, it was suggested that pilots should think gate to gate rather than take-off to landing. No recommendation was offered.

Note: The report submitted by Transport Canada's SCRI recommends an amendment be made to the Transport Canada Flight Instructor's Guide in order to place additional emphasis on radio-telephony procedures and ICAO standard phraseology. Familiarity with simultaneous intersecting runway operations, pre-planning and briefing of intended taxi routes prior to arrival and departure as well as minimising other cockpit tasks while taxing were also highlighted in the list of recommendations.

3.5 Vehicle/Pedestrian Deviations (VPD)

Most circumstances surrounding vehicle and pedestrian deviations result from breaches in security. The statistics have revealed a strong correlation between construction activity at an airport and the number of incursions.

Normally, incursions of the protected space around a runway are not investigated. The Airside Vehicle Operator Program (AVOP) is a comprehensive program under the direction of the airport authority that provides instruction and testing for operators before they are permitted to operate on or near runways and taxiways. Several of the visited sites have rigorous monitoring programs and respond when infractions are noted. At other sites, not all runway incursions are reported. Some airport authorities have developed remedial training programs for employees involved in runway incursions while others have penalties that include counseling, demerit points, and loss of privileges.

- Recommendation # 12

   The panel suggested that airport authorities be encouraged to develop remedial training programs for employees involved in runway incursions.

Some sites have developed an "Inter-Job Awareness" programs. These locally administered programs permit controllers and specialists to ride in maintenance vehicles during routine activities and vehicle operators in the tower cab to observe the ATC operation. Many ATS personnel at the meetings do not participate in the program and are not aware of the distractions that exist for vehicle operators such as high noise levels, monitoring of multiple frequencies or cellular telephone. Conversely, vehicle operators are not always familiar with any changes in the operations areas of ATS facilities. The resulting effect is an apparent lack of appreciation for the other's job.

3.6 Incursion Statistics

- **Total number of reported incursions:** 1998 – 120

    1999 – 213

    2000 – 286
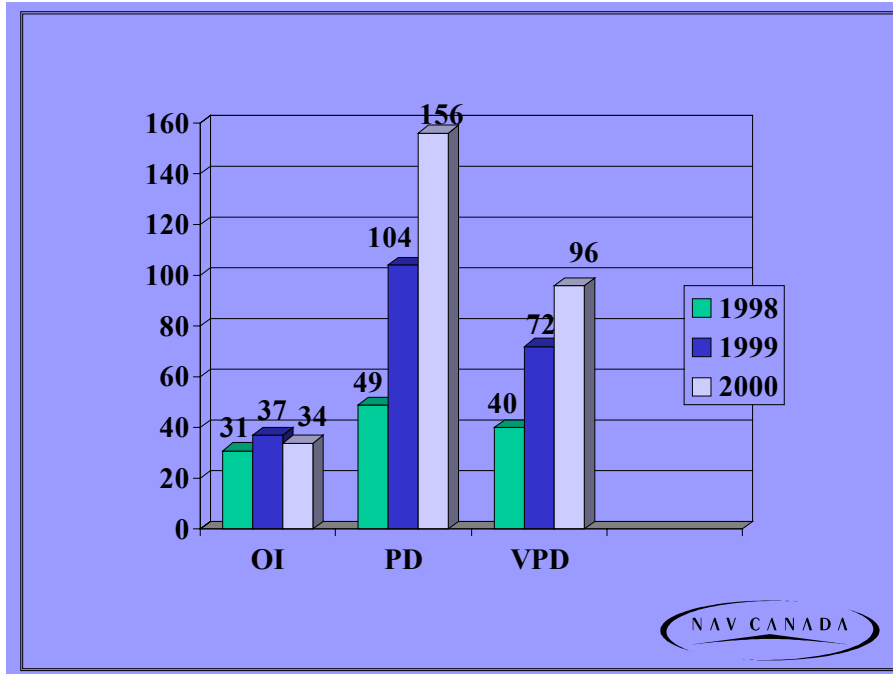
Breakdown of runway incursions by type.

While the US statistics are similar in breakdown to Canadian figures, the definition, type of airport – controlled/uncontrolled and risk assessment used in Canada are different.

US statistics suggest that an extremely high accident potential exist in 55% of operating irregularities, 44% of pilot deviations, and 33% of vehicle/pedestrian deviations. This high percentage (55%) indicates that a greater accident risk exists when an incursion is the result of an ATC action that mistakenly authorizes an aircraft or vehicle onto a runway. Pilot and vehicle operator mistakes result in lesser risk potential for accident.

3.7 Communications

Failures in effective communication have been proven to be a contributing factor to runway incursions. The Aviation industry has witnessed numerous advances in aerodynamics, power plant efficiency and reliability, flightdeck automation, and navigation systems. ATS/aircraft communications have changed little over the years and still exhibit the age-old limitations of natural and human-made interference. Examples that were provided by the stakeholders at the safety roundtable meetings include: (1) distorted messages,(2) language barriers, and (3) problems of pronunciation and phraseology. The communications errors reported during these meetings are also mentioned in the Grayson and Billings (1981) report that categorizes errors caused by *technical problems (*frequency congestion), non-*linguistic (*failure to provide necessary information or failure to monitor transmissions), and *linguistic (*ambiguous phraseology, inaccurate phraseology and misinterpreted phraseology). Continued efforts at improving communications were stressed during the meetings. These efforts include refresher training and stringent monitoring of ATS communications.

Normal ATS communications procedures require the controller/specialist to issue or relay a clearance to an aircraft, listen to the pilot response in order to verify the accuracy of the response. This practice of "Readback/hearback" is a means of mutual verification between pilots and controllers/specialists and is an essential built in redundancy in ATS communications. A web search has revealed that recent American studies have shown this redundancy to be frequently missing from exchanges of critical aviation information.

Pilots who attended the meetings confirmed their dislike for the ATC procedure of transmitting information and instructions on two or more frequencies simultaneously. This is particularly confusing to low time pilots who do not understand the practice.

- Recommendation # 13 (See also recommendation 11)
  The panel suggested that NAV CANADA continue to include "professional communications" as a subject of annual refresher training for controllers and FSS. This recommendation is closely related to recommendation # 11 but will be considered as a separate teaching point for operational staff.

Some airline representatives stated they do not like being taxied to a take-off position on the ground control frequency. The resulting loss of monitoring capability of the tower frequency plus the loss of visual cues of arriving aircraft reduces traditional safeguards and sets the stage for potential serious consequences. A practice, used at some American sites, requires the controller to select one frequency for the combined position and to advertise the combined position and associated frequency on the automated terminal information service (ATIS).

3.8 Signage and Markings

See also section 3.4.3

Information gathered from the NAV CANADA database indicates that some incursions can be attributed to confusion with airport signage or marking, even if the markings are in compliance with TP 312.
Examples of confusing signage and markings were found at Calgary during airside visits
A series of particularly complex runway/taxiway intersections and routes was also found in Toronto.

In the USA, some aviation experts have suggested that there is far too much concrete with far too many options at large airports. Some American officials suggest that perhaps it is time to think "outside the box" and close taxiways that can lead to confusion to help reduce the incursion risk. Information gleaned from the Web indicates that one American airline company is planning on changing their operating procedures at a major US airport. The new procedure will have their aircraft taxi around the ends of active runways, rather than cross them.

Comments such as "There is better signage on Highway 401 than at some airports", "confusing", "impossible to see during dark, rainy evenings" were offered by participants at roundtable meetings. An Internet survey conducted by Avweb in April 2000 identified inadequate and/or confusing airport signs and markings as the most important factor contributing to runway incursions. Air Canada officials pointed out there can be problems with signage due to the difference in "eye-to wheel" height between wide-bodied aircraft (high cockpit) and smaller aircraft such as the regional jet (low cockpit).

Some initiatives used by the Los Angeles World Airport Authority were presented during each site meeting for discussion purposes. "Hold" lines are painted at Los Angeles LAX airport every 2-3 weeks while Canadian "hold" lines are painted once and occasionally twice during the year. Other Los Angeles initiatives include doubling the width of hold lines from 6" to 12", and the painting of a contrasting background (black) prior to line painting. The initiative also included the painting of mandatory hold signs on the taxiway prior to the hold lines, elevated runway guard lights (wig-wags), and in-pavement stop bars. The Air Canada representative on the expert panel was uncertain of the effectiveness of elevated runway guard lights or "wig-wags". Most runway entry points at Toronto International airport have "wig-wags". Some Canadian airport authorities have begun to emulate some of the Los Angeles practices.

No recommendation was provided on this issue.

3.9 ATS Procedures

During each safety roundtable meeting, relevant ground control procedures were examined and discussed. The procedures that the expert panel reviewed are listed below:

3.9.1 Taxi to position

There was general consensus at roundtable meetings and with the expert panel on this issue. It was agreed that aircraft should not be put into position on the active runway if a delay in the issuance of a take-off clearance is anticipated. The expert panel did not quantify "delay".
The recent recommendations of the National Transportation Safety Board (NTSB) regarding the phraseology for an aircraft going to position on the active runway as well as the overall procedure were also reviewed.

- Recommendation # 14

   The panel suggested that ATC procedures be modified so that aircraft are **not** taxied into position on a runway if a delay for take-off clearance is anticipated.

The adoption of the ICAO recommended phraseology of "line-up and wait" was discussed.

- Recommendation # 15
   The expert panel suggested the phraseology be considered at the next Air Traffic Services Advisory Group (ATAG) meeting

3.9.2 Intersection departures

Runway Incursion research by the FAA has determined that intersection take-offs can be dangerous. The Vancouver representative informed the panel that there are 13 intersections on runway 08R/26L where aircraft can take off and suggested there is limited value to multi-intersection departures in high intensity operations. It was shown that intersection departures could create delays because of the requirement to provide wake turbulence separation. The site visits determined that some ATC units are currently including the intersection point in the "taxi to position" and "take-off clearance" phraseology.

The expert panel endorsed the use of "minimal departure points" i.e. midfield and threshold. It was suggested that there is no requirement to change the existing ATC procedures and that each site, through their ops committee, review current practices to determine the most efficient procedures for intersection departures.

- Recommendation # 16
   The expert panel recommended that NAV CANADA ATS provide direction to operational sites regarding the limited use of intersection departures.

3.9.3 Standard taxi routes

Vancouver airport has established a series of "standard taxi routes" and published them in the CAP. Comments received during the site visit and from the Vancouver expert panel representative indicate little or no problems with these routes. The Toronto LBPIA practice of using standard taxi routes has been suspended due to the partial closure of taxiways and the ongoing construction projects on or near the aircraft manoeuvring areas.

Considerable discussion at the site meetings revolved around the possibility of publishing standardized taxi routes thereby reducing the communication requirements for taxiing aircraft and frequency congestion.

Comments received from representatives of a major courier operator suggested the recommendation of a standard operating practice within his company that would require flight crews to copy all taxi clearances.

- Recommendation # 17
  The expert panel recommended that ATS Site Managers should identify the requirement for standard taxi routes and publish the routes as necessary through consultation with local site operations committees.

3.9.4 Taxi-authorization to cross all runways

 The American National Transportation Safety Board (NTSB) recently recommended that an authorization be required to cross or enter all runways whether they are active or not. A successful test of this procedure was conducted by controllers at Winnipeg International airport during the fall of 1999 with positive results. Some Calgary air traffic controllers have adopted use of this procedure because of the numerous incursions at the airport.

- Recommendation # 18
  The panel of experts agreed that authorization should be required for all aircraft/vehicles movements to cross runways, whether active or not. This procedure would be consistent with established FAA procedures.

3.9.5 Mandatory Frequency (MF) Deviations

NAV CANADA fact-finding board reports and other internal investigations indicate that many of the incursions reported at uncontrolled airports are the direct result of non-conformance to the Mandatory Frequency requirements by pilots. Transport Canada has taken a zero-tolerance approach to the MF problem through enforcement procedures.

- Recommendation # 19 (See also 4.3)
  Faced with this information, the expert panel identified a need for continuing pilot education and problem awareness through existing Transport Canada documentation.

FSS procedures do not permit the specialist to transmit simultaneously on the MF and the ground frequency. This results in ground vehicles on the ground frequency not being able to hear or communicate with the pilot of a taxiing aircraft on the MF. This procedure can lead to runway incursions.

- Recommendation # 20
  The panel of experts suggested the feasibility of selecting several test sites to implement an interim vehicle control service through simultaneous transmissions on the MF and ground control frequencies. These selected test-sites would provide a cross-section of traffic volumes and weather conditions and would include tests with "hold short" instructions. See 3.9.7.

3.9.6 Determination of active runway at uncontrolled airports

NAV CANADA reports indicate that the use of opposite ends of active runways ("runway roulette") by pilots at uncontrolled airports is commonplace. Many aircraft operators will use the "out of wind" end of a runway to save time and fuel and conflicting with aircraft who have chosen the runway most aligned into the wind, as per the CARs.

- Recommendation # 21
  The panel felt this problem could best be dealt with by the Air Traffic Advisory Group (ATAG) and suggested that NAV CANADA examine the possibility of having FSS coordinate with the parent ACC to establish the active runway

3.9.7 FSS authorization to restrict aircraft on the ground from entering the active runway

There was considerable discussion at the Expert Panel meeting regarding this item. By authorizing FSS to issue hold short restrictions, an additional enhancement to safety could be gained.

This was seen as an internal procedural problem that could be resolved by discussions between the NAV CANADA Airspace & Procedures section and Legal Services. This issue will also be submitted to ATAG for discussion. Recommendation # 20 has been applied to section 3.9.5, MF deviations. The feasibility of "hold short" instructions at those selecting FSS test-sites during the provision of vehicle control service on the mandatory frequency falls under the same recommendation.

4.0 Other issues

4.1 Technology

Many of the technologies that are under development or have been developed to minimize incursions were reviewed. Authorities in the US have pointed out in the available literature that technology should not be complicated. James Hall, Chairman of the U.S. National Transportation Safety Board stated that technology intended to reduce the potential for runway incursions is "long on promise and short on performance".

NAV CANADA has installed the NOVA 9000 ATCS ground radar system at Toronto International airport. The Rannoch Corporation has been awarded a contract to install a similar ground radar system at Calgary International airport. The effectiveness of each radar system will be tested/validated. There has been one instance in Toronto where controllers were alerted of an impending incursion and provided with enough warning time for corrective action to be taken.

Many pilots who attended the site visits used the term "information overload" to describe today's cockpit environment. It was suggested that the introduction of new "glass" technology in both aircraft and ATS may be contributing to an occasional loss of situational awareness and may require changes in operating procedures for pilots and controllers. The airport members of the expert panel suggested a need for "partnering" with industry officials to address the technology issue with a low cost solution being the ideal result. The solution would be a system that would alert the pilot of an impending "hold" line.

- Recommendation # 22
  The panel suggested that airport authorities consider the installation of an inductive-loop system similar to the system in operation at Long Beach, California at high-risk airports.

4.2 Airport Diagrams

The site visits revealed that many Canadian general aviation (GA) pilots do not have access to large scale, high detail airport diagrams. The GA pilot must rely on the small aerodrome diagram available in the Canada Flight Supplement while pilots who have access to the Canada Air Pilot or Jeppesen plates have comprehensive, high detail maps.

Research on the Web has indicated that the Aircraft Owners and Pilots Association has placed high detail diagrams of 320 airports in the USA on the Web. This allows pilots who have web connectivity to download and print any of these diagrams free of charge. Concern was expressed about copyrights of the diagrams while others stated they would be willing to put their airport diagrams on their own airport web sites. This inconsistency would not satisfy the requirements of the aviation community because of the be hit and miss approach to the publishing of aeronautical information on the web.

As a result of a recommendation by the FAA Runway Action Plan, authorities at some major US airports and FAA facilities have developed large wall-size airport diagrams with hazardous intersections and potentially high incidence incursion areas clearly marked. These diagrams are distributed to all flight planning offices, flight schools, and airline dispatch offices.

- Recommendation # 23
  The expert panel suggested that low cost diagrams of controlled airports be made available to general aviation pilots. The panel also suggested that discussions should be initiated with the regulator aimed at regulating and enforcing the requirement for pilots to carry the necessary airport diagrams.

4.3 Communications in the Aviation Community

- Most runway incursion "experts" agree that there is a need for education, awareness, and training for pilots, ATS personnel, and airport authority personnel. All participants on the expert panel agreed with the principle that there is a requirement for a spirit of cooperation amongst all facets of the aviation community (users, stakeholders, provider, and regulator). Panel members suggested that NAV CANADA endorse the existing TC safety letter and the COPA newsletter as the vehicles to be used to promulgate the magnitude of the problem to the pilot community.

4.4 Related Issues

An electronic search and review of the literature on preventative activities relating to runway incursions has indicated that the most effective approach to reducing runway incursions is through the principle of education, awareness and training (EAT). The research has shown that an increase in the expenditure of time, money, and effort in these areas should, in all probability, result in a reduction in the number of incursions. No recommendation was offered by the panel on this subject

Discussions on other related issues generated much interest. These discussions presented the panel chair with the opportunity to capture the following recommendations:

Recommendation # 24:

The expert panel identified a need to convene a "task force" to implement runway incursion reduction strategies. The panel suggested that a task force be created in partnership with Transport Canada and major stakeholders, to implement runway incursion reduction strategies.

- Recommendation # 25
  It was suggested by some that fast-time simulation being used at the NAV CANADA facility in Ottawa could be used to assess the incursion risk at high incidence sites. This facility may provide some insight/solutions to high-risk areas at some airports based on simulated traffic flows.

- Recommendation # 26

  Some panel members suggested that NAV CANADA establish a recognition program for sites meeting zero incursion events. The program would be similar to the existing "Awards of Excellence" program. In addition, consideration should be given to the development of a high intensity poster program of "Push It Up" (Awareness & Attentiveness) to "Bring It Down" (Operating Irregularities). The continuation and expansion of existing bulletins and safety newsletters should be explored with the OSQM and the Airspace and Procedures section.

- Recommendation # 27
  Re-evaluate position relief/handoff phraseology and scanning techniques.

5.0 Conclusion

This study has shown that the management of the risk associated with runway incursions rests with the entire aviation community and not only the service providers such as NAV CANADA.

The one recurring theme heard throughout this study was a call for a partnership between Federal agencies, the aviation community and NAV CANADA. The recommendations from this study can provide the impetus toward that need. Negotiations should occur with the Transport Canada sub-committee on runway incursions and NAV CANADA to form a work team to implement recommendations from both incursion studies.

Annexe A - RECOMMENDATIONS:

1. Adopt a new definition to capture runway incursion events: "*Any occurrence at an airport involving the unauthorized or unplanned presence of an aircraft, vehicle, or person on the protected area of a surface designated for aircraft landings and departures*".

2. Assign a severity factor to each reported occurrence. The expert panel recommended the following severity definitions be used:
f.   **Negligible** - the occurrence would not have caused a collision between aircraft or vehicles. No intervention required to keep the runway clear. *(Example: An aircraft or vehicle was near (within 200 feet) but not on a serviceable runway and stopped short of the runway surface without intervention).*
g.   **Low** - the occurrence was unlikely to result in a collision between aircraft or vehicles. ATC or pilot intervention was required to keep the runway clear. *(Example: A vehicle or aircraft was near (within 200 feet) but not on a serviceable runway and stopped short of the runway surface when contacted by ATC).*
h.   **Medium** - the occurrence could have resulted in a collision between aircraft or vehicles. A vehicle or aircraft was on a serviceable runway without authorization or was cleared onto (or across) a serviceable runway by mistake. *(Example: An aircraft crosses a serviceable runway without clearance).*
i.   **High** - the occurrence could have resulted in a collision between aircraft or vehicles. A vehicle or aircraft was on a serviceable runway without authorization or cleared by mistake and a **clear risk of collision** existed. Normally requires ATC intervention to correct. *(Example: Two aircraft take off from the same runway at the same time).*
j.   **Extreme** - the occurrence would have resulted in a collision between vehicles and/or aircraft and was prevented only by **last minute evasive action** by the aircrew and/or vehicle operator(s). *(Example: A pilot rejects a take-off to avoid a collision with a vehicle or another aircraft)*

3. Create improvements to the existing Runway Incursion database and to the AOR classification criteria to lessen the amount of time required to review occurrence reports and extract the pertinent information.

4. Redesign the NAV CANADA runway incursion database to include all required fields (uncontrolled/controlled, severity factor). Safety & Service Design or the Office of Safety & Quality Management should control database design and input. Provide outside agencies with password protected read-only access to the incursion database. Local authorities and stakeholders expressed this need during site visits.

5. Develop a formalized "Runway Incursion" presentation and continue the runway incursion educational process within NAV CANADA.

6. Continue to provide an awareness program to all airport employees (NAV CANADA and Airport Authority) during site visits. The visits would also deal with pertinent issues at the site and should include other operational subjects such as MF and SIRO. + NAV CANADA could chair bi-annual meetings at all major airports to discuss mutual problems with the Canadian Airports Council, Canadian Owners and Pilot's Association, and all levels of carriers. Establish a focal point (team) within NAV CANADA to continue efforts to address the runway incursion problem.

7. Meet with Transport Canada to discuss an awareness program for airport vehicle operators.

8. Decide on the requirement for a standard national incursion warning system. Since there is a wide-range of alerting devices and memory aids in place across the country, the effectiveness and usefulness of each should be re-evaluated.

9. Remind site managers and supervisors of their responsibilities regarding functional goal #1: Full-time attentive flight monitoring.

10. Ensure that authorities conduct a more rigorous monitoring of ATS phraseology and procedures, including random tape checks and real time on-site monitoring.

11/13. Continue to include "professional communications" as a subject of annual refresher training for controllers and Flight Service specialists.

12. Encourage airport authorities to develop remedial training programs for employees involved in runway incursions.

14. Modify procedures so that aircraft are **not** taxied into position on a runway if a delay for take-off clearance is anticipated.

15. Consider the adoption of the ICAO recommended phraseology of "line-up and wait". The expert panel suggested the Air Traffic Services Advisory Group (ATAG) as the forum for this issue.

16. Provide direction to all ATS units regarding the limited use of intersection departures.

17. Identify the requirement for standardized taxi routes and implement the routes as necessary at the site level.

18. Modify current regulations to require authorization for aircraft/vehicles to cross all runways whether active or not. This procedure will be consistent with FAA procedures.

19. Endorse the existing TC safety letter and the COPA newsletter as the vehicles to be used to promulgate the magnitude of the problem to the pilot community.

20. Investigate the feasibility of selecting FSS sites to implement, on a test basis, the provision of vehicle control service through simultaneous transmissions on the mandatory frequency and ground control frequency.

21. Examine the possibility of having FSS coordinate with the parent ACC to establish the active runway. The panel felt this item could also be dealt with by the Air Traffic Advisory Group (ATAG).

22. Consider the installation of an inductive-loop system at high-risk areas, similar to the system in operation at Long Beach, California.

23. Provide low cost diagrams of controlled airports to general aviation pilots. Discussions should be initiated with the regulator to make it a regulated and enforceable requirement for pilots to carry the necessary airport diagrams.

24. Convene a task force in partnership with Transport Canada and major stakeholders, to implement runway incursion reduction strategies.

25. Conduct fast-time simulation to assess the incursion risk at high incidence airports. The ATS facility in Ottawa may provide some solutions based on traffic flows.

26. Establish a recognition program for sites meeting zero incursion events. The program would be similar to the existing "Awards of Excellence" program. In addition, consideration should be given to the development of a high intensity poster program of "Push It Up" (Awareness & Attentiveness) to "Bring It Down" (Operating Irregularities. The continuation and expansion of existing bulletins and safety newsletters should be explored with the OSQM and the Airspace and Procedures section

27. Re-evaluate position relief/handoff phraseology and scanning techniques.

Notes