Australian Government

Australian Transport Safety Bureau

AVIATION SAFETY RESEARCH PAPER

Runway Incursions: 1997 to 2003

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RESEARCH REPORT

Runway Incursions:
1997 to 2003

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EXECUTIVE SUMMARY

Although most runway incursions do not result in accidents, the potentially catastrophic consequences of runway incursions place them high on the agendas of aviation safety agencies internationally.

The definition of a runway incursion used by the ATSB is provided in regulation 2.2 of the *Transport Safety Investigation Regulations 2003*: '*any intrusion of an aircraft, vehicle, person, animal or object on the ground within a runway strip or helicopter landing site that creates a collision hazard or results in a reduction of safety for aircraft.*'

The majority of runway incursions in Australia have a low potential to result in an accident. Australia has never experienced a large scale accident due to a runway incursion but vigilance is required to maintain this safety record.

Data described and analysed in this report were sourced from the ATSB's OASIS database. The data have been reviewed and analysed to better understand runway incursions in Australia by way of addressing the following questions.

a) Have incursions increased or decreased?

Statistical tests revealed no significant differences in incursion rates across the years for the towered aerodrome groups studied, with the exception of a statistically significant increase in incursions for GAAP aerodromes in 2003 and a marginally significant increase for Class C aerodromes in 2003 largely because of an increase at Darwin. Given this relatively recent increase in incursions, it is not possible to ascertain whether it is likely to become an ongoing trend.

b) What are the main reasons for incursions?

The ATSB's review and analysis generally supported previous research about the causes of runway incursions. The data indicated that the large majority of incursions (79 per cent at Class C and D, 91 per cent at GAAP aerodromes) were due to communication problems between and controllers and another party, usually a pilot.

Aerodromes differ in their configuration complexity, traffic mix and volume and in their use of capacity-enhancing procedures such as parallel runways. All these factors have been previously identified as contributing to runway incursions (Transport Canada, 2000). This report has not focused on causes at specific aerodromes where factors combine in unique ways to increase the probability of runway incursions. However, the complexity of these factors should be remembered when considering the causes of runway incursions.

c) How does the rate of incursions in Australia compare with other countries?

Incursion rate comparisons

Although reports containing figures on runway incursions have been released by the United States, Canada and Europe, direct rate comparisons were not possible. This was due to methodological and definitional differences in the data. It was possible, however, to compare Australian data with United States and European data based on the severity of the occurrences.

Incursion severity comparison
The occurrences were classified into four levels of severity based on the definitions used in the FAA report on this topic (FAA Office of Runway Safety, 2000). Low severity incursions were events that satisfied the definition of an incursion, but involved little or no risk of a collision; high severity incursions required immediate action to avoid an imminent collision.

Australia and the US experienced 92 per cent and 81 per cent of low severity 'level d' incursions, indicating that the majority of runway incursions were not likely to result in an accident. The data indicated that the Australian incursion rate was higher than the US rate, even when definitional differences were countered. The comparison with the European data was limited due to the assumptions being made, but suggested that Australia had more low severity and less high severity incidents than the European sample.

d) How significant is the risk to Australian aviation safety?

In 92 per cent of cases the severity was low, producing minimal accident potential to the aircraft involved. Runway incursions presented a serious accident potential in two out of every million operations.

Viewed in comparison with other reportable events, incursions were atypical events that rarely posed a serious accident risk. However, given the potential catastrophic consequences of incursions, it would not be prudent to become complacent about them. It should be remembered that at Class C and D aerodromes, high capacity Regular Public Transport (RPT) traffic and low capacity RPT traffic is involved in 31 per cent and 11 per cent of incursions respectively.

Overall, the data confirm the need for constant vigilance and the implementation of all practicable measures for reducing runway incursions.

BACKGROUND

Runway operations are controlled through a complex system of technology and procedures applied by pilots and air traffic controllers (ATC). These systems work toward mitigating risks to aircraft when they are moving around aerodromes, in close proximity to other aircraft, vehicles, people or animals. Separation standards at the different phases of taxiing, takeoff and landing are usually well maintained by these methods. However, as with any human–machine interface, there is always the possibility of human error, mechanical malfunction or a combination of both.

While runway incursions are relatively rare events, they have the potential to result in catastrophe. A recent example and Italy's worst aircraft accident, was a runway incursion at Milan's Liante aerodrome on 8 October 2001. The pilot of a Cessna Citation CJ2 mistakenly taxied onto an active runway on which a SAS Scandinavian Airlines MD-87 was accelerating for take off. The MD-87 hit the Cessna on rotation. The Cessna was destroyed at the site of the impact while the airliner skidded off the runway crashing into a baggage hangar. The accident resulted in 118 deaths, including four deaths of ground personnel (King, 2002).

1.1 Definitions

In general terms runway incursions are a *potential* or *actual* breakdown of separation standards caused when an aircraft, vehicle, person or animal ventures onto a runway in an unauthorised manner.

There is currently no standard definition of runway incursions adopted by the International Civil Aviation Organization (ICAO). However, there is work in progress on the harmonisation of definitions. The ICAO Air Navigation Commission's working definition of a runway incursion is '*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 takeoff of the aircraft*.' (Hughes, 2003). This definition is expected to be adopted as a standard by ICAO by the end of 2004.

After this definition has been adopted, ICAO is proposing the adoption of a standardised global definition of runway incursion severity. This would allow an easy exchange of runway incursion data among countries, greatly increasing the data available for analysis and thereby improving the identification of problems and the appropriate direction of resources.

The Federal Aviation Administration (FAA) in the United States defines runway incursions as '*any occurrence in the airport runway environment involving an aircraft, vehicle, person, or object on the ground that creates a collision hazard or results in a loss of required separation with an aircraft taking off, intending to take off, landing, or intending to land.*' (FAA Office of Runway Safety, 2003).

This definition requires two objects to be present to constitute a threat to safety. For example, the unauthorised entrance of a vehicle onto a runway would not be considered an incursion unless an aircraft was on or approaching that runway.

Nav Canada, in consultation with Transport Canada, propose that incursions are '*any occurrence at an aerodrome involving the unauthorised or unplanned presence of an aircraft, vehicle or person on the protected area of a surface designated for aircraft landings and departures.'* (Transport Canada, 2000). Similarly, in Europe, Eurocontrol consider incursions to be the '*unintended presence of an aircraft, vehicle, or person on the runway or runway* *strip'*. Both these definitions intend that a single aircraft, vehicle or person acting in an unauthorised manner on a runway, is a threat to safety (Safety Quality Management and Standardisation Unit, 2001).

The ATSB's definition of a runway incursion, as found in regulation 2.2 of the *Transport Safety Investigation Regulations 2003*, is similar to the Canadian and European definitions. It states that a runway incursion is '*any intrusion of an aircraft, vehicle, person, animal or object on the ground within a runway strip or helicopter landing site that creates a collision hazard or results in a reduction of safety for aircraft.'*

This definition encompasses all instances where a reduction in safety occurs regardless of the immediate danger posed to an aircraft. It includes situations that lead to aircraft, vehicles, people or animals being present on a runway in an unauthorised or unintended manner, with or without the presence of an aircraft on or approaching the runway. This stance has been adopted in order to maintain the focus on safe runway practices, including all situations where, but for good fortune, an aircraft may have been in immediate danger.

The definition adopted by the ATSB is different from the proposed ICAO definition which specifically excludes animal and object incursions.

1.2 Reasons incursions occur

The FAA Office of Runway Safety (2001) classify runway incursions into three major categories:

a) *operational errors* that are generally the result of erroneous ATC instructions;
b) *pilot deviations* that are the result of pilots not complying with instructions for various reasons; and
c) *vehicle, pedestrian and animal intrusion*s that result when these enter a runway in an unauthorised way.

Operational errors and pilot deviations account for the majority of runway incursions. Investigations into these events routinely uncover three main human errors that contribute to bring about the incursion (Flight Safety Information, 2002). They are:

a) *ineffective communications* resulting from pilot/controller interactions such as inaccurate read backs (especially omitting 'hold short' directions);

b) *lack of aerodrome knowledge (*pilots unfamiliar with aerodrome layouts and taxi routes); and

c) *improper cockpit procedures (*pilots distracted by checklists or talking about irrelevant matters when taxiing instead of scanning the ground).

Factors such as runway and taxiway complexity, the volume and type of air traffic and the number of catering and maintenance vehicles, combine to increase the risk of unauthorised activities and subsequent breakdowns of separation (Transport Canada, 2000).

Incursions are rare events because of the use of surface operation radar, standard phraseology and aerodrome charts, enforcement of regulations and procedures that include instructions from ATC, and labelling of runways and taxiways.

Although most runway incursions do not result in accidents, the potentially catastrophic consequences of runway incursions place them high on the agendas of aviation safety agencies internationally. The worst accident in aviation history occurred in 1977 as a result of a runway incursion. Two Boeing 747s collided on a runway at Tenerife, resulting in the loss of 583 lives. Some examples of runway incursions typically experienced in Australia follow.

Occurrence Number: 199703645

The pilot of a Cessna was on the taxiway awaiting clearance to enter the runway for departure.
A Brasilia aircraft was on final approach for the same runway and had been cleared to land by
the aerodrome controller. The pilot of the Cessna was given the instruction that the Brasilia
was on short final and that when the Brasilia was clear the Cessna could 'line up'. The controller said he then looked around to sight other circuiting aircraft and when he looked back towards the runway, the Cessna had entered the runway in front of the landing Brasilia.
The controller attempted to contact the pilot of the Cessna, but there was no response. The controller then informed the Brasilia about the Cessna's presence. The Brasilia was consequently able to land safely on the shortened length of runway.

Occurrence Number: 200103433

The crew had received a clearance to land on runway 35 when the aerodrome controller (ADC) saw a truck cross the holding point at taxiway Delta and approaching the runway. The ADC instructed the crew to go around from final. The ADC then saw that the truck had stopped and was reversing away from the runway. The truck vacated the runway strip as the aircraft crossed the threshold during the go around. The ATSB investigation found that the route used by works vehicle was not marked across taxiway Delta. Consequently, when the driver was distracted with work tasks and was temporarily unaware of his position on the aerodrome, he mistakenly turned onto Delta instead of taxiway Foxtrot.

1.3 International research

The FAA found that, despite efforts to control runway incursions, they were still increasing with an 'alarming trend'. Programmes introduced in the mid 1990s designed to reduce incursion rates by 80 per cent were confronted with a 54 per cent increase in 1997 (Mead, 1997). Research conducted at that time indicated that incursions were primarily being caused by pilot deviations, and that general aviation aircraft were involved in 72 per cent of pilot deviations. The research recommended both local and system-wide solutions to this problem, but no details were provided (FAA Office of Runway Safety, 2000).

Other research conducted by the FAA completed an extensive investigation of incursion severity as measured by frequency, proximity and speed of aircraft (FAA Office of Runway Safety, 2001). This research confirmed that:

- incursions are infrequent events and collisions are rare;
- the diversity of runway configurations and traffic mix make comparisons between aerodromes problematic;
- current data collection methods do not have the required level of detail to determine 'root causes' as opposed to attributing the error to a person; and
- commercial or general aviation operations are not overly represented in incursion statistics.

In Canada, the same upward trend in runway incursions was documented by both Nav Canada and Transport Canada (TC) (Transport Canada, 2000). The TC report recognised the potential rise in incursions as traffic at an aerodrome increased and deduced that a rise in potential incursions will result in a rise in actual incursions. These increases were mainly attributed to the use of capacity enhancing procedures like parallel runway operations, simultaneous intersection operations and intersection departures. Recommendations made in the report centred on better training and increased awareness, standardised rules and procedures including ATC protocols, improved data collection, and continued research into the causes and prevention of incursions.

Eurocontrol, the European organisation for air navigation safety, has also recognised the importance of this issue and undertaken similar research. Its survey of eight European aerodromes revealed that incursions accounted for 26 per cent of all runway safety issues. Pilot deviations and operational errors were identified as the main event types that led to incursions. ATC and pilots surveyed considered phraseology to be the most important human factor involved, and the most important physical factor to be aerodrome layout and signs (Safety Quality Management and Standardisation Unit, 2001).

Research conducted by the Honeywell company and presented at the Flight Safety Foundation's 55th International Air Safety Seminar in 2002, focused on a limited worldwide sample. The findings were similar to previous work in the area and identified procedures or deviations from procedures, decision making and failure to anticipate, communication and visual monitoring and awareness of traffic as contributors to runway incursions (Khatwa, 2002).

In Australia, there have been several independent reports commissioned by specific groups within the aviation industry, but a national review of runway incursions has yet to be completed. This report is a first step towards better understanding the risk posed by runway incursions to the Australian travelling public.

OBJECTIVES

The scope of this report is limited to statistical data compiled by the ATSB between calendar years 1997 and 2003. The report aims to provide a descriptive overview of runway incursions at Australian aerodromes, rather than an in-depth analysis of causes and possible remedies. To do this the report has been largely limited to aerodromes with operational towers. It attempts to answer the following fundamental questions:

a) Have incursion rates increased or decreased?

b) What are some of the major characteristics of incursions?

c) How does Australia compare with other countries?

d) How significant is the risk to Australian aviation safety?

METHOD

The study was completed over two time periods on two different data sets. The first analysis was released as a discussion paper for public comment in July 2003. This final version of the report incorporates components of this analysis based on data from 1997 to 2001. The analysis of national figures, trends, contributing factors and the relationship between the level of aerodrome traffic and incursions was completed in 2004 based on data for the calendar years 1997 to 2003.

The methods of identification of runway incursions and classification were identical for both data sets. However, some inconsistencies may have resulted from revision of the data over time and changes in coding practices. This does not affect the conclusions of the report.

3.1 Identifying runway incursions

Aviation incidents, serious incidents and accidents reported to the ATSB are recorded in the Occurrences Analysis and Safety Investigation System (OASIS) database. The majority of runway related occurrences are reported to the ATSB by Air Traffic Control (ATC) through Airservices Australia's Electronic Safety Incident Report (ESIR) system.

For both the 1997 to 2001 data set and the 1997 to 2003 data set, incidents were identified in a three stage process. Firstly, the OASIS database was searched for all accidents and incidents identified as runway incursions. Secondly, occurrences classified as actual or potential collisions with aircraft, objects or other movable features including vehicles, animals or people, where they occurred on a runway, were incorporated. Finally, occurrences where there was no air traffic control tower operating at the time of the occurrence or where the occurrence was outside Australian airspace were removed from the analysis.

The report focuses on occurrences where a traffic control tower was operational as sufficient information is frequently not available for meaningful analysis of many occurrences falling outside this definition. It was also theorised that the reporting rate of occurrences at times when there was no tower operational would not be consistent, thereby leading to distortions in the data.

The query yielded a total of 857 occurrences at aerodromes throughout Australia. It should be noted that the total number of occurrences may differ somewhat from other figures reported by the ATSB and other organisations, due to the definitions used and the revision of the data.

Runway incursions were also represented in Airservices Australia's general aviation system safety enhancement reports (GASSERs). These reports are a means for controllers at general aviation aerodromes to report minor occurrences involving general aviation aircraft that are normally resolved with the operators by the local air traffic control units. These events are not considered serious enough to constitute an electronic safety incident report that would find its way into the OASIS database. GASSERs contain no details of the event and serve only as a tally of events. This system began in late 1998 and, while incursions reported in this manner are acknowledged, they have not been included in the current report due to lack of data for the calendar years 1997 and 1998 and their lack of detail.

3.2 Classifying the data

Incursions for each aerodrome were collated. The aerodromes were then grouped by the type of airspace in which they are situated or the type of operation they performed. This yielded the groups of Class C, Class D, General Aviation Aerodrome Procedures (GAAP) and 'Other Military'.

Class C aerodromes include Melbourne, Adelaide, Perth, Darwin, Cairns, Townsville, Brisbane, Coolangatta, Sydney and Canberra.

Class D airspace extends below some Class C 'steps' to the ground over designated aerodromes that do not have a local radar display. These aerodromes include, Hobart, Launceston, Albury, Tamworth, Coffs Harbour, Maroochydore, Rockhampton, Mackay and Alice Springs.

GAAP is a set of procedures that are designed to regulate traffic into and out of very busy controlled aerodromes that usually handle light aircraft. The GAAP aerodromes in Australia are Archerfield, Bankstown, Camden, Jandakot, Moorabbin and Parafield.

Essendon aerodrome is unique in that while it is within Class C airspace and does have some of the facilities of the larger aerodromes, such as local radar display, its traffic mix is similar to a GAAP aerodrome. For this reason it was considered more appropriate to place Essendon in the GAAP aerodrome classification.

In this report 'Other Military' aerodromes, refer to aerodromes that primarily handle military aircraft. These include Amberley, Nowra, Oakey, Pearce, Richmond, Williamtown and Tindal. Towers that are staffed by military controllers but service civil operations, like Townsville and Darwin are not included in this grouping. Occurrences at 'Other Military' aerodromes were not investigated in detail as incursions at these aerodromes have little impact on civil aviation.

Other regional aerodromes represent the remaining airfields in Australia that recorded runway incursions in this period. However, occurrences at these aerodromes were not investigated due to the relatively low impact on fare paying passengers and the small number of incursions per aerodrome. It is also theorised that reporting of occurrences at these aerodromes is low.

3.3 Aerodromes and their primary traffic type

This report focuses on incursions at aerodromes with operational air traffic control towers. The group 'Other Military' aerodromes are only represented in the section 'National figures'. Aerodromes in Class C and D airspace process the majority of Regular Public Transport (RPT) aircraft and so process the vast majority of fare-paying passengers. GAAP aerodromes are mainly used by general aviation traffic. When the groups are combined, the data represent incursions that occurred at aerodromes with operational towers.

3.4 Incursion measures

The data were analysed in three ways: incursion types, incursion rates per million operations, and incursion severity. Incursion types were measured using the entire data set and helped to identify which incursion type (aircraft, vehicle, people or animal) were most involved in incursions. Incursion rates per million operations were only calculated for Class C, D and GAAP aerodromes.

In order to assess the seriousness of runway incursions, a set of severity levels were applied to data for 1997 to 2001. This period was chosen in order to make international comparisons. Incursion incident reports were independently assessed and categorised by two ATSB investigators with extensive Air Traffic Control experience. This process categorised the severity of each incident by assessing operational dimensions like reaction time available, corrective action, speed and proximity of aircraft. After each incursion had been allocated to a severity level, the rate per million operations was calculated for each severity level.

3.5 Contributing factors

A study of the contributing factors to runway incursions was conducted on the entire data set from 1997 to 2003. Human factors such as communication, aerodrome knowledge and cockpit procedures were identified. Operation types such as RPT, charter, training and general aviation were also examined. This information was collated from OASIS database entries that had been coded using the Systemic Incident Analysis Model (SIAM). This model classifies incidents according to the real, potential or apparent outcomes, the defences that failed and what types of failures occurred, as well as the recovery measures employed.

3.6 Aerodrome traffic

An analysis of the relationship between the level of aerodrome traffic and the number of incursions during each hour of the day was conducted on Class C aerodromes. Darwin and Townsville aerodromes were excluded from the analysis as suitable traffic data were not available. A count of the number of arrivals at Class C aerodromes by hour in 2003 was obtained from Airservices Australia and was used as a measure of aerodrome traffic in a given hour. The underlying assumption in this analysis is that the pattern of arrivals at each airport has been relatively constant over the seven year period. Incursion data were then matched to these data.

In order to take into account differing levels of traffic and time zones for each airport, every hour in the day was assigned a rank from 1 to 24 based on the number of arrivals at the airport in that hour during 2003 (1 being the lowest level of arrivals, 24 being the highest). The matching incursion data were than sorted from highest to lowest by this rank and summed to obtain a Class C total of the number of incursions by relative traffic level in airspace.

The variation in the rate of incursions across time was assessed by calculating a rate of incursion per hour for each airport. The analysis used a negative binomial model to analyse any statistically significant variation in the rates over the day.

3.7 Severity level comparisons

This component of the analysis and research was conducted separately and completed in early 2003 using data for 1997 to 2001. There are many circumstances surrounding runway incursions that combine to produce a variety of outcomes. These outcomes vary from negligible to severe consequences, but few incursions result in collisions. For example, when an aircraft crosses an active runway without a clearance with no other aircraft in the vicinity, there is a low potential for an accident. Alternatively, when an aircraft crosses a runway where another aircraft is starting its takeoff roll, a high potential exists. The following examples illustrate the range of outcomes. Both occurrences involve mistakenly crossing a runway, however, the potential for an accident is far greater in the second occurrence.

Occurrence Number: 200100850
While taxiing on taxiway charlie, the crew were advised to turn left and line up on runway 16L. However, the aircraft was observed to turn right onto the taxiway bravo 10 intersection and cross the holding points for runway 16R. No other aircraft was present and no breakdown of separation occurred.

Occurrence Number: 200101636
During the landing roll on runway 11C, the pilot of the Airtourer aircraft failed to comply with an ATC instruction to 'Hold short of runway 11L'. The Airtourer was observed to turn left into taxiway T and began crossing runway 11L, where an aircraft had become airborne just after taxiway M. The pilot was instructed to stop but had already infringed runway 11L. The pilot of the airborne aircraft veered left and passed ahead and above the Airtourer.

In order to better describe the potential for an accident in the current sample of incursions, the following classification levels were applied to data for 1997 to 2001 (see Table 1)[1]. The categories were designed to better describe the range of severity displayed in runway incursions using five operational dimensions. These dimensions are:

- available reaction time
- evasive or corrective action
- environmental conditions
- speed of aircraft and/or vehicle, etc.
- proximity of aircraft and/or vehicle, etc.

The dimensions were categorised and are listed below, with *d* being the least serious and *a* being the most serious incident before a collision or accident occurs[2].

[1] This taxonomy was used in the *FAA Runway Safety Report: Runway incursion severity trends at towered aerodromes in the United States 1997–2000*. FAA Office of Runway Safety, June 2000.
[2] For the purposes of this report, collisions with animals were assessed in view of the potential damage to the aircraft and its occupants rather than placed in the accidents category.

TABLE 1:
Severity Levels

Level	*Description*
d	Little or no chance of collision, but met the definition of a runway incursion.
c	Separation decreased, but there was ample time and distance to avoid a potential collision.
b	Separation decreased and there was a significant potential for collision.
a	Separation decreased and participants took extreme action to narrowly avoid a collision.
Accident	An incursion that resulted in a collision.

The Australian severity data were compared with US and European data that had been categorised under the same taxonomy. Differences in incursion definitions and data collection methods and reporting tendencies must be considered when interpreting these results.

RESULTS

4.1 National figures

Between 1997 and 2003, 857 runway incursions occurring at Class C, Class D, GAAP and Military airports were identified from the ATSB's OASIS database. The data showed that no major accidents resulted from runway incursions in the period studied. The only actual collisions that did occur were with animals and the remaining occurrences were potential collisions only.

The data were grouped by aerodrome and by the type of airspace in which the aerodrome is located. The results from these groupings are reported in Table 2. The majority of incursions occurred at aerodromes in Class C airspace (371 incursions) and GAAP aerodromes (378 incursions). Aerodromes in Class D airspace (81 incursions) and 'Other Military' (27 incursions) aerodromes had notably fewer incursions.

Of the 857 incursions reported, 85 per cent were due to an aircraft, five per cent were due to animals[3], eight per cent were due to vehicles and two per cent were due to people. The majority of incursions at all aerodrome classes were due to errors that resulted in an aircraft being on a runway in an unauthorised manner.

TABLE 2:
Summary of reported runway incursions - Australia 1997 and 2003

	Class C	Class D	GAAP	Military	Total	
Responsibility for incursion					Number	Per cent[4]
Aircraft	281	60	361	22	724	85
Vehicle	53	7	5	1	66	8
Person	4	7	5	0	16	2
Animal	30	6	4	3	43	5
Total incidents[5]	371	81	378	27	857	100

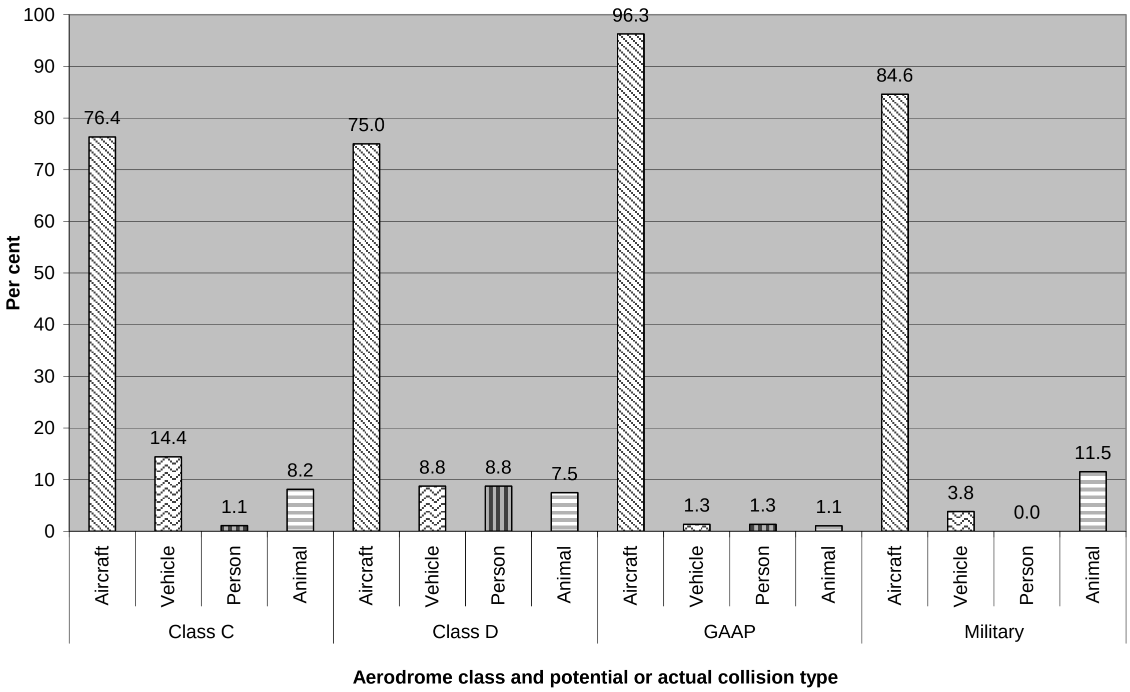
[3] However, bird, bat and gliding possum strikes are not considered runway incursions.
[4] Eight cases where potential or actual collision type was unknown were excluded from the calculation of per cents.
[5] Includes eight cases where potential or actual collision type was unknown.

Figure 1 illustrates that aircraft are the most likely incursion object in all aerodrome classes analysed, and while vehicles, people and animals pose a risk, they are relatively minor sources of incursions.

Class C aerodromes recorded 14.4 per cent of incursions as being due to a vehicle, compared with 8.8 per cent for Class D aerodromes, 1.3 for GAAP aerodromes and 3.8 per cent for military aerodromes. This may be related to the amount of vehicle traffic servicing higher capacity aircraft within these larger aerodromes. GAAP aerodromes recorded 96.3 per cent of incursions as being due to an aircraft, compared with 76.4 per cent for Class C, 75.0 per cent for Class D and 84.6 per cent for military aerodromes.

An in-depth analysis of the reasons for these differences is beyond the scope of this report. However, while it appears there are some differences between the aerodrome classes, it should be noted that the total numbers of incursions are relatively small, particularly at the GAAP and military aerodromes among the vehicle, person and animal incursion categories.

FIGURE 1:
Type of incursion by aerodrome class - Australia 1997 to 2003



4.2 Incursion trends over time

The number of annual runway incursions in the Class C category ranged from 41 in 2002 to 70 in 2003 (see table 3). The considerable increase in 2003 is largely due to an increase in incursions at Darwin aerodrome where incursions jumped from 9 in 2002 to 23 in 2003. It is not known what caused this large increase. There is no clear increasing or decreasing trend in the number of runway incursions over the 1997 to 2003 period at Class C aerodromes.

TABLE 3:
Runway incursions by aerodrome class - Australia 1997 to 2003

	1997	1998	1999	2000	2001	2002	2003
Aerodrome class							
Class A	46	59	53	50	52	41	70
Class D	16	10	13	4	9	15	14
GAAP	37	63	48	54	55	53	68

The number of incursions at Class D aerodromes fluctuated considerably from year to year. Incursions at Class D aerodromes ranged from 4 in 2000 to 16 in 1997.

GAAP aerodromes experienced fluctuations, with a low of 37 in 1997 and a high of 68 in 2003. Bankstown contributed most incursions in the GAAP category, with an average of 34 incursions annually. For reasons stated earlier, incursions reported in the GASSER system have not been included in GAAP figures.

Caution should be used in interpreting the number of incursions over time, as the rate of reporting is known to fluctuate, particularly for lower severity occurrences. Unfortunately, it is not possible to quantify the amount of underreporting.

4.3 Incursion Rates

Although the overall rate of runway incursions per million operations for the period is lower for Class D aerodromes (29) than for Class C (43) and GAAP (38) there were no statistically significant differences between these three classes (p=0.6). In other words, based on the data available, no aerodrome class had a significantly higher rate of incursions. There are jumps in 1998 and 2003 for Class C and GAAP aerodromes. The pattern is much more variable for Class D aerodromes.

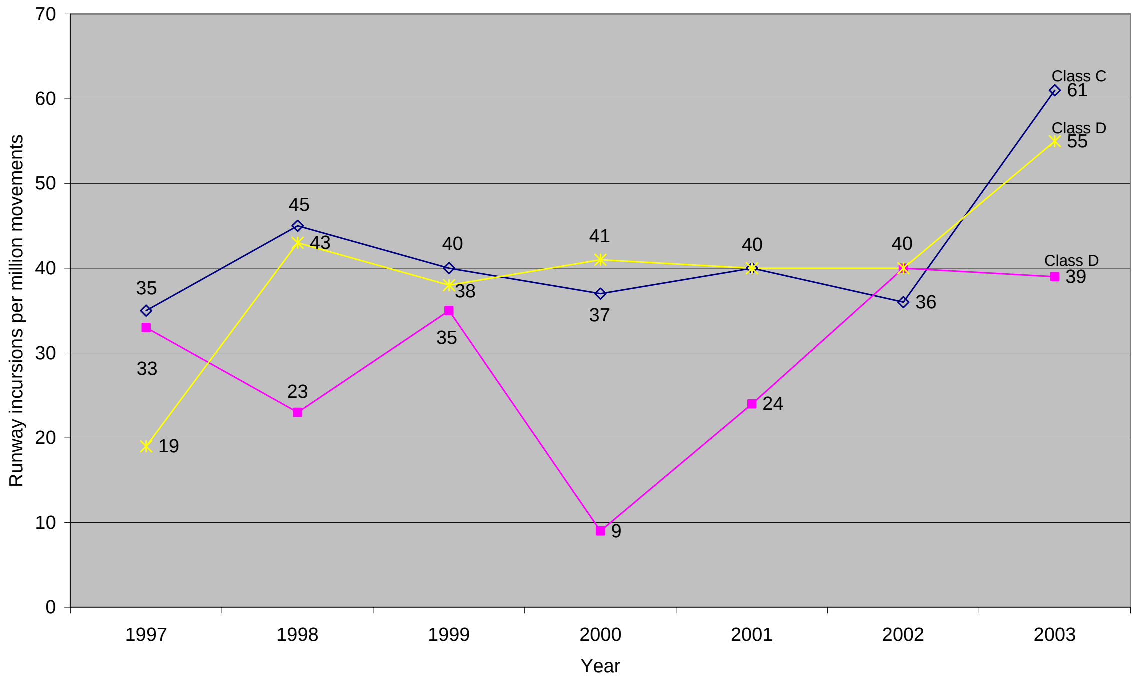
Figure 2 shows the rate in Class C aerodromes ranged from 25 incursions per million aircraft movements in 1997 to 61 in 2003. The data did not support a statistically significant increasing trend for Class C (p=0.3). There was a marginally statistically significant jump in 2003 compared with previous years (p=0.08, relative rate 1.8). The exclusion of 1997 from the analysis revealed a similar result (p=0.08, relative rate=1.7). The increase in the 2003 rate mostly reflects the large increase in incursions at Darwin airport.

Class D aerodromes ranged from nine incursions per million aircraft movements in 2000 to 40 in 2002. There was no statistically significant trend in the Class D rates (p=0.5).

The rate of incursions per million aircraft movements at GAAP aerodromes ranged from 19 in 1997 to 55 in 2003. There was evidence of an increasing trend (p=0.008). There was also evidence of a statistically significant jump in 2003 compared with previous years at GAAP aerodromes (p=0.003, relative rate 1.6 with 95% confidence interval 1.2, 2.3). The exclusion of 1997 from the analysis revealed a similar result (p=0.04, relative rate=1.5).

Caution must be used in making comparisons of incidents over time and between aerodrome classes, as differences in reporting culture and differences in reporting rates over time can influence the figures. This is exacerbated by the fact that the numbers are relatively small.

FIGURE 2:
Runway incursion rates for each airspace group - Australia 1997 to 2003



4.4 Contributing factors

The data indicated that 79 per cent of incursions at Class C and Class D aerodromes and 91 per cent at GAAP aerodromes, involved a breakdown in communication between ATC and another party, such as a pilot or ground staff. In 75 per cent of cases, incursions resulted when communication of clearances and instructions provided by ATC to pilots were not complied with or not properly understood. Changes to radio procedures were introduced in 1998 and their inconsistent application caused confusion at the time. However, as incursion rates have remained fairly stable, this is unlikely to have been a major contributing factor. Using the data available, it was not possible to hypothesise about what may have caused these communication problems.

The remaining factors identified as being involved in runway incursions were varied and involved only a relatively small number of runway incursions. These included:

- other communication problems (three per cent at Class C and D, six per cent at GAAP);
- flight rule related (none at Class C and D, six per cent at GAAP);
- errors in procedures and standards (six per cent of incursions at Class C and D, one per cent at GAAP); and
- aerodrome animal control (eight per cent of incursions at Class C and D, one per cent at GAAP).

In most cases the error was attributed to the pilot (85 per cent), with air traffic control in error in eight per cent of cases. While these figures tend to support an anecdotal presumption of pilot error, they must be viewed with some caution. The result may be the product of reporting biases brought about by the fact that most incursions are reported by ATC, providing details from a traffic control point of view.

From the available data it is also not possible to determine the type of flying operation (RPT, charter, training etc.) most often responsible for runway incursions. Table 4 shows that the majority of data records classified the type of operation as unknown (39 per cent for class C and D aerodromes, 72 per cent for GAAP aerodromes), indicating that this information was unavailable at the time of entry into the database.

Examination of the data records where the type of operation had been identified indicated that the number of incursions was proportional to the volume of the type of flying operation generally carried out in the area. This means that Class C and D aerodromes carry a majority of RPT traffic and have a majority of incursions involving RPT traffic (high capacity RPT - 31 per cent, low capacity RPT- 11 per cent). GAAP aerodromes carry a majority of general aviation traffic and have a majority of incursions due to general aviation traffic (training- 19 per cent, private – 6 per cent).

TABLE 4:
Incursions by operation type involved - Australia 1997 to 2003

	Type of operation (per cent)						
	HCRPT	LCRPT	Charter	Training	Private	Other	Unknown
Aerodrome class							
C and D	31	11	6	3	4	6	39
GAAP	0	1	1	19	6	1	72

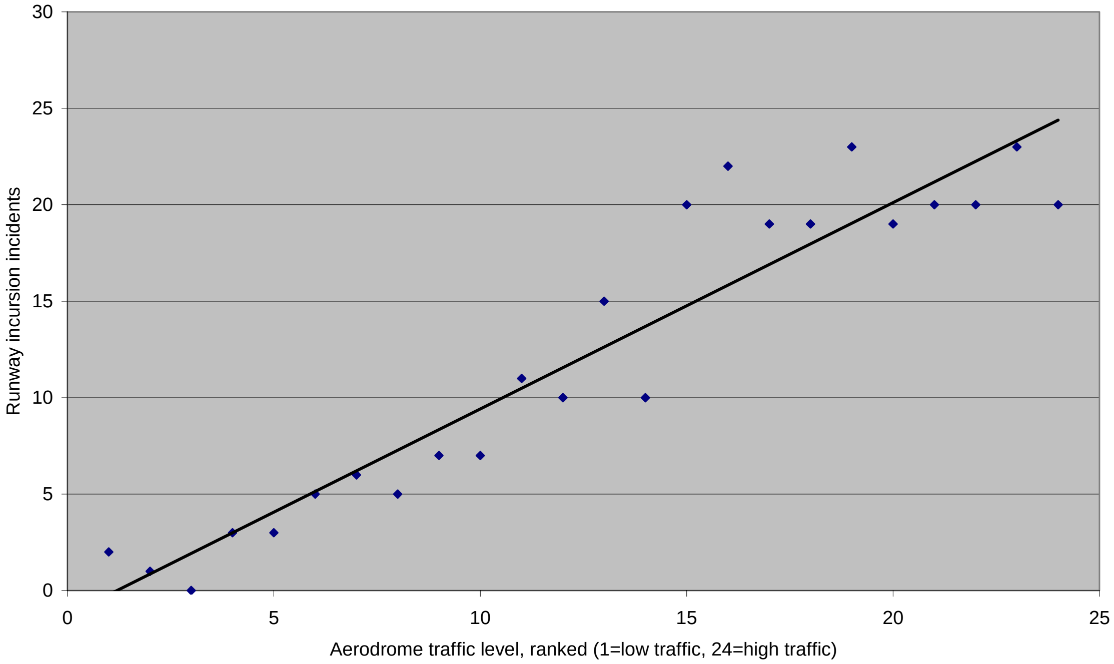
4.5 Aerodrome traffic

An analysis of the relationship between aerodrome traffic and the number of incursions was completed for Class C aerodromes. Darwin and Townsville were excluded from this analysis as no suitable aerodrome traffic data were available. Arrival data for the year 2003 was used as a measure of aerodrome traffic by hour.

Figure 3 shows the number of incursions by the ranked level of traffic per hour[6]. As would be expected, the analysis found there was a positive relationship between the number of incursions and the traffic level. An assumption was made in this analysis that the relative traffic levels by hour did not change over the period 1997 to 2003. The analysis is intended to be indicative of the relationship between incursions and traffic levels.

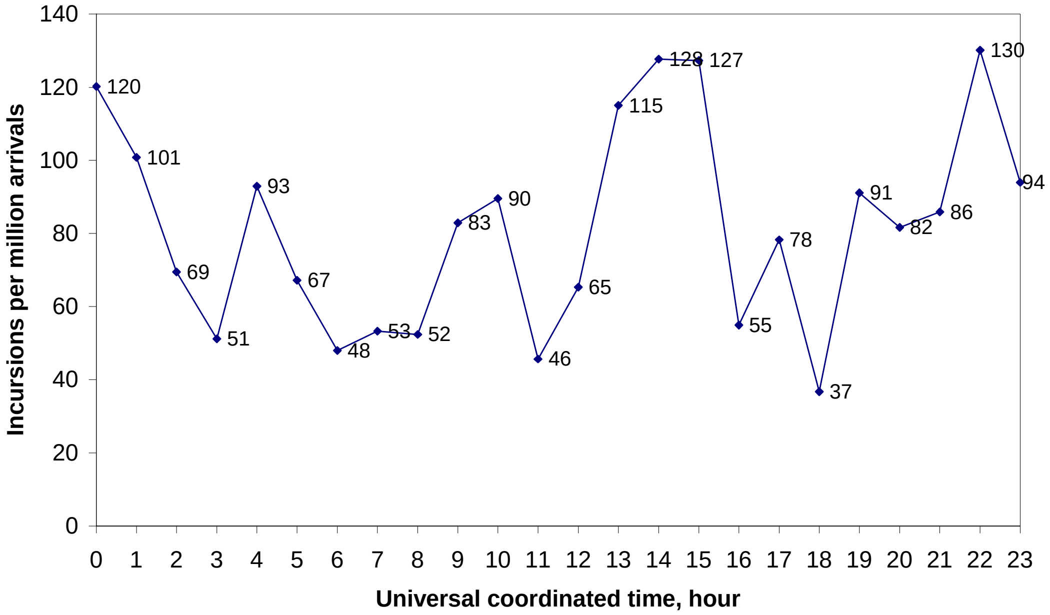
[6] The method of this analysis is discussed in the 'Method' section of this report.

FIGURE 3:
Number of runway incursions at eight Class C aerodromes by the relative traffic level - Australia 1997 to 2003



The variation in the rate of incursions per million aircraft arrivals across time of day and night was assessed statistically, using a negative binomial model. Figure 4 illustrates that there was no smooth trend across time. The statistical modelling indicated there were no statistically significant differences in the rate across time (p=0.1). This indicates that there is no evidence to suggest that incursions are more or less likely at certain times, once adjustment is made for the amount of aircraft activity.

FIGURE 4:
Incursion rates per (million aircraft arrivals) by time of day summarised across eight Class C airports - Australia 1997-2003

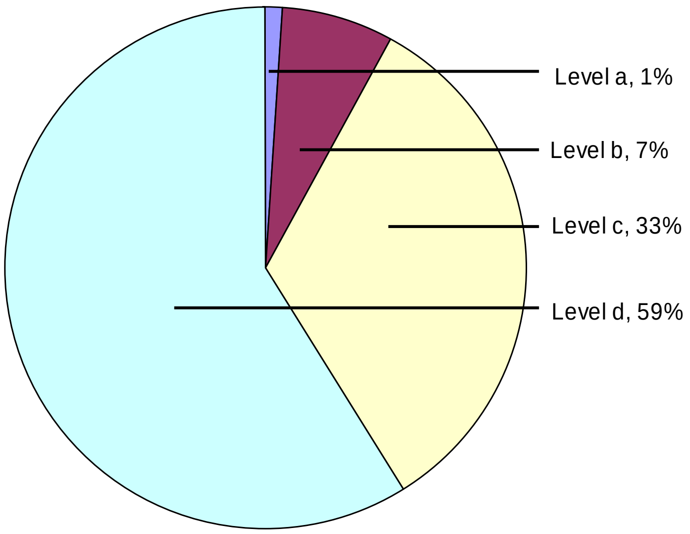


4.6 Severity levels

An analysis on the severity of runway incursions occurring between the years 1997 to 2001 was carried out. Figure 5 shows the severity levels for the Australian sample of runway incursions. Descriptions of these levels were presented in section 4. The majority of incidents were categorised as low severity, levels *d* and *c*. In these cases, there was little or no threat of an accident, but the definition of a runway incursion was satisfied or separation decreased but separation standards were not broken and there was ample time and distance to avoid a collision. These figures indicate that in the five years studied, 92 per cent of incursions at aerodromes with operating towers were unlikely to result in an accident.

The remaining incursions were classified as seven per cent level *b*, where a significant accident threat existed, and one per cent as level *a* where extreme action to avoid an accident was required. Combined, these levels represent a moderate to high possibility of an accident occurring.

FIGURE 5:
Breakdown of severity levels - Australia 1997 to 2001

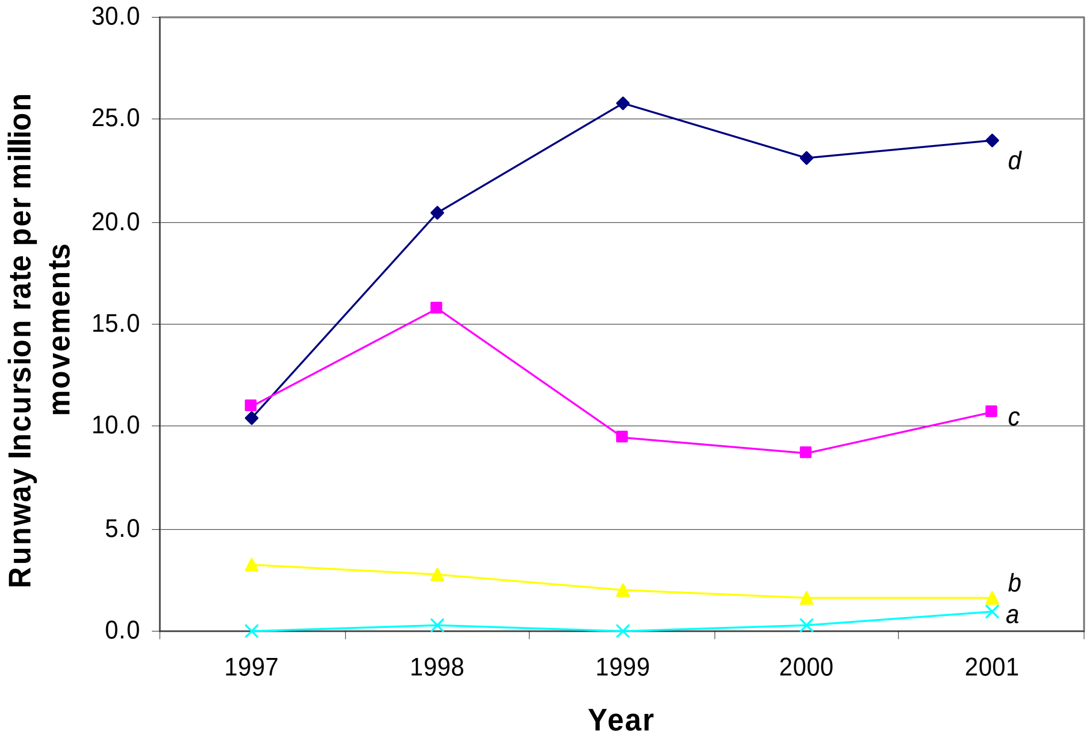


Closer inspection of the causal factors behind incidents classified as level *a* and *b* severity matched previous findings that incursions were commonly brought about by aircraft entering or crossing runways in an unauthorised manner. The data indicated that communication problems between air traffic control and pilots were most often the source of the level *b* incursions. Deficiencies in pilot knowledge, skill and experience and pilot attention was the source of three of the four level *a* incidents. Level *a* and *b* incidents were reported by ATC in most cases.

To identify possible trends in the severity data, a Chi-square analysis was conducted. Levels *a* and *b* were combined due to the small numbers to yield a three (level) by five (year) frequency table. The results indicated statistically significant differences in the severity distribution across years for the three levels.[7] This indicated that based on actual numbers, there were significant changes in the severity levels across the years. The differences are most likely to be attributable to a relative increase in low severity incursions between 1997 and 1999. This increase has been graphed in Figure 6.

[7] $\chi 2 = 24.1$, df = 8, $p < .005$.

FIGURE 6:
Runway incursions rates overall- Australia 1997 to 2001



4.7 Severity rates

This component of the analysis was completed in 2003 using a different data set from that used for the analysis of 1997 to 2003 data. A summary of these data is presented in table 5.

TABLE 5
Runway incursions - Australia 1997 to 2001

Airspace class	*Number of runway incursions*	*Runway incursions per million aircraft operations*
Class C	267	38
Class D	49	23
GAAP	233	33
Class C, Class D and GAAP	558	34

4.7.1 Severity rates over years

The overall incursion rate for the period 1997 to 2001 was 34 incursions per million operations. After the severity of the incursions was assessed, it was revealed that 92 per cent of incursions were classified as low severity (*d* and *c* level). The overall rate of 34 incursions per million operations can be divided into two components – 32 low severity incursions (level *d* and *c*) and two high severity incursions (level *b* and *a*) per million operations (table 6).

TABLE 6:
Overall Severity Levels- 1997 to 2001

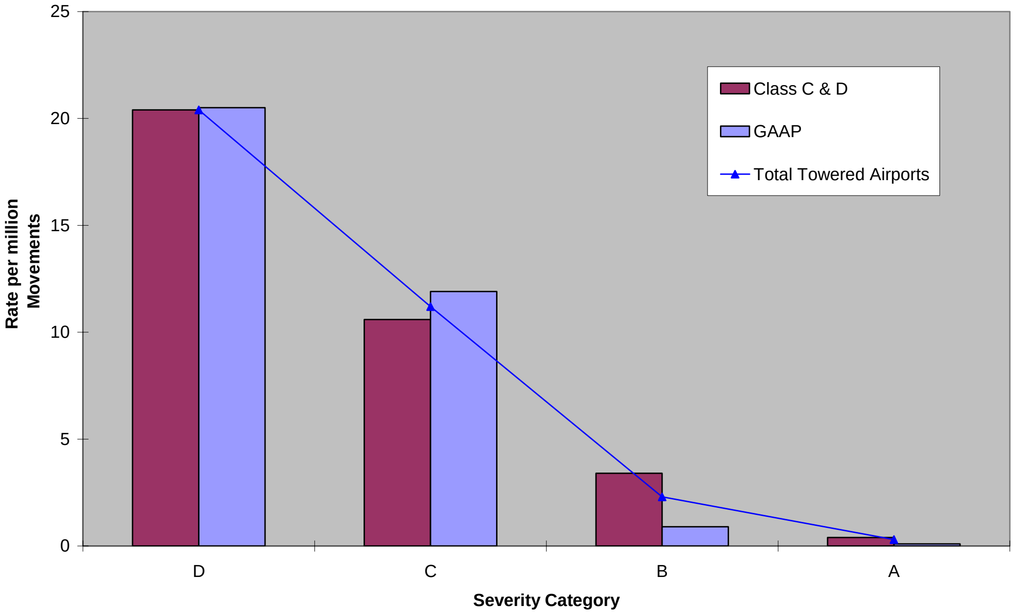
Level	*Description*	*Incursions per million operations*
d	Little or no chance of collision but met the definition of a runway incursion.	21
c	Separation decreased but there was ample time and distance to avoid a potential collision.	11
b	Separation decreased and there was significant potential for collision.	2
a	Separation decreased and participants took extreme action to narrowly avoid a collision.	0.3

Incursion severity rates were calculated, effectively controlling the effect of aircraft operations. The overall increase in incursions from 1997 to 1998 was still evident and the increase was sustained through to 2001 (figure 6). This indicates that the increase between 1997 and 1998 was not solely due to an underlying increase in aircraft activity. A Poisson model was fitted to the rates to evaluate the statistical significance of possible trends and differences. The analysis indicated that the increase between 1997 and 1998 was a statistically significant increase of 50 per cent, but there were no differences for the remaining years. Overall, the data revealed a significant increase from 1997 to 1998 but remained stable for the rest of the years.

4.7.2 Severity level rates – combined class C and D and GAAP aerodromes.

To recap, aerodromes have been grouped as Class C and D combined and GAAP, and severity levels have been labelled as *d, c, b* and *a*. Figure 7 illustrates that both aerodrome groupings (Class C and D combined and GAAP) reported similar rates of low level severity (*d* and *c*) incursions. Class C and D aerodromes reported slightly elevated rates of level *b* and *a* severity incursions in comparison to GAAP aerodromes. Statistically, there is no difference in the severity level of incursions at different aerodrome types. Of note are the results for Sydney and Canberra aerodromes that accounted for 22 and 17 per cent respectively of the severe (level *a* and *b*) incursions for Class C and D aerodromes.

FIGURE 7:
Severity rates per million operations - Australia 1997 to 2001



4.8 United States data

Data for this analysis was taken from *Runway Incursion Severity Trends at Towered Aerodromes in the United States* in June 2001, and the follow up in June 2002, produced by the Federal Aviation Administration Office of Runway Safety. Rates for the available years are shown in figure 8.

The US data showed a marked increase in incursions between 1999 and 2000 that was still evident when rates per million operations were calculated. This indicates that the increase was not solely due to changes in traffic volume. The number of million aircraft operations were estimated by back calculating from the rates reported and a Poisson model was fitted to evaluate the increase. The analysis indicated that the rates for 2000 and 2001 were significantly greater than in the earlier years. An estimated increase of 28 per cent was found.[8]

The US data were also analysed using the same severity ratings discussed earlier (figure 6 & 7). Again, the data were dominated by low severity (*d* and *c*) incidents. Figure 8 shows the distribution of severity levels and highlights the recent increase in low level incidents. A Chi-square test comparing 1997 – 1999 combined data with the later years indicated a statistically significant difference between these two periods.[9]

It is possible that the runway incursion awareness campaign conducted by the FAA in recent years has encouraged the reporting of runway incursions that had previously seemed not important enough to report. This is supported by the finding that once the less severe (level *d*) incidents were removed, there was no significant increase in incursion rates.[10] In summary, incursion rates in the United States increased markedly between 1999 and 2000 and this increase was maintained in 2001. The increase in incursions has been driven by low severity incursions while level *c*, *b* and *a* severity levels have remained constant.

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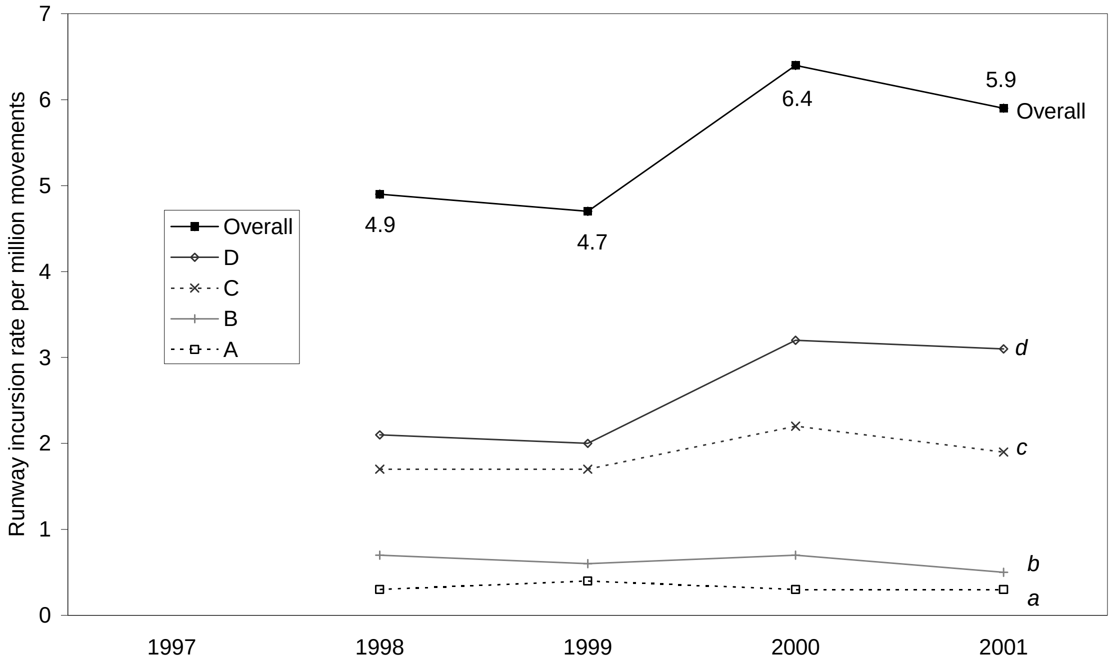
[8] The estimated rate ratio for 2000/2001 vs 1998/1999 was 1.28 with 95% confidence interval (1.16 – 1.42).

[9] A collapsed 4 (level) by 2 (period) table combining the earlier period 1997–1999 and the later period 2000 and 2001 was significant. (χ^2=14.15 df=3, p= 0.005).

[10] If the low severity incursions (*d*) are excluded the annual rate per million movements becomes 2.7, 2.7, 3.2 and 2.7 for the years 1998 to 2001 respectively, and no statistically significant differences are observed between these rates either across the 4 years or comparing 1998-1999 with 2000 –2001.

FIGURE 8:
Runway incursions rates overall - United States



4.9 Comparison with United States data

The United States data indicated that on average 81 per cent of incursions were of low severity compared with 92 per cent in Australia for the period 1997 to 2001. Higher numbers of low severity incidents are to be expected in the Australian sample primarily due to definitional differences that will inflate the proportion of low severity occurrences. Both samples exhibit an increase of the less severe *d* incursions and the subsequent decrease in more severe *a, b* and *c* incursions in recent years which is shown in figures 9 and 10.

FIGURE 9:
Runway Incursion Severity Distribution- United States 1997 to 2001

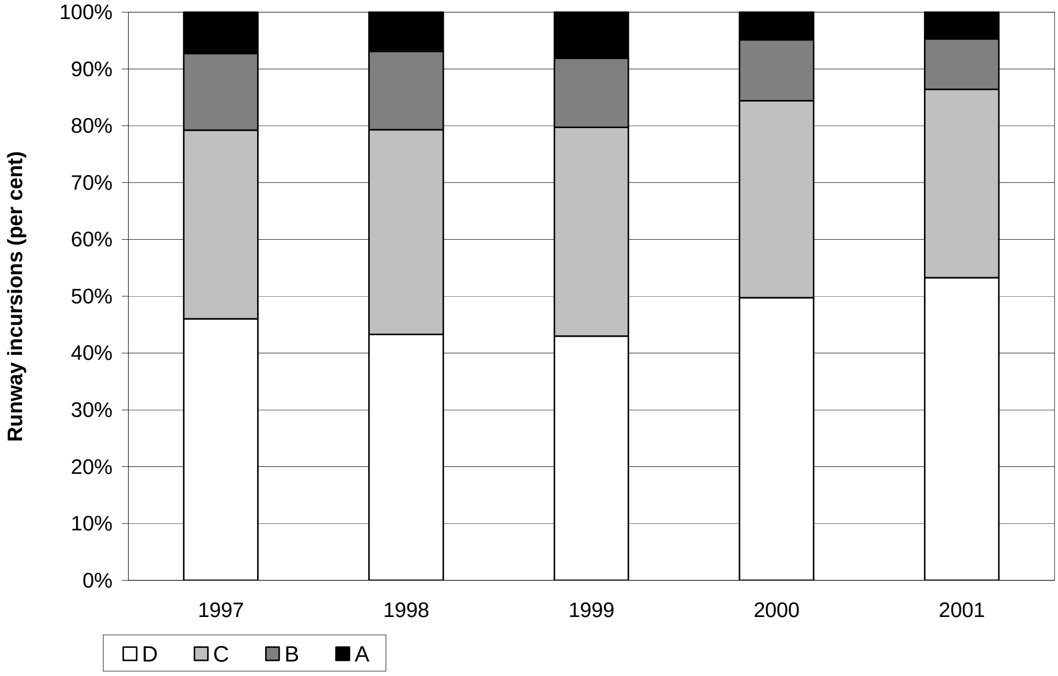
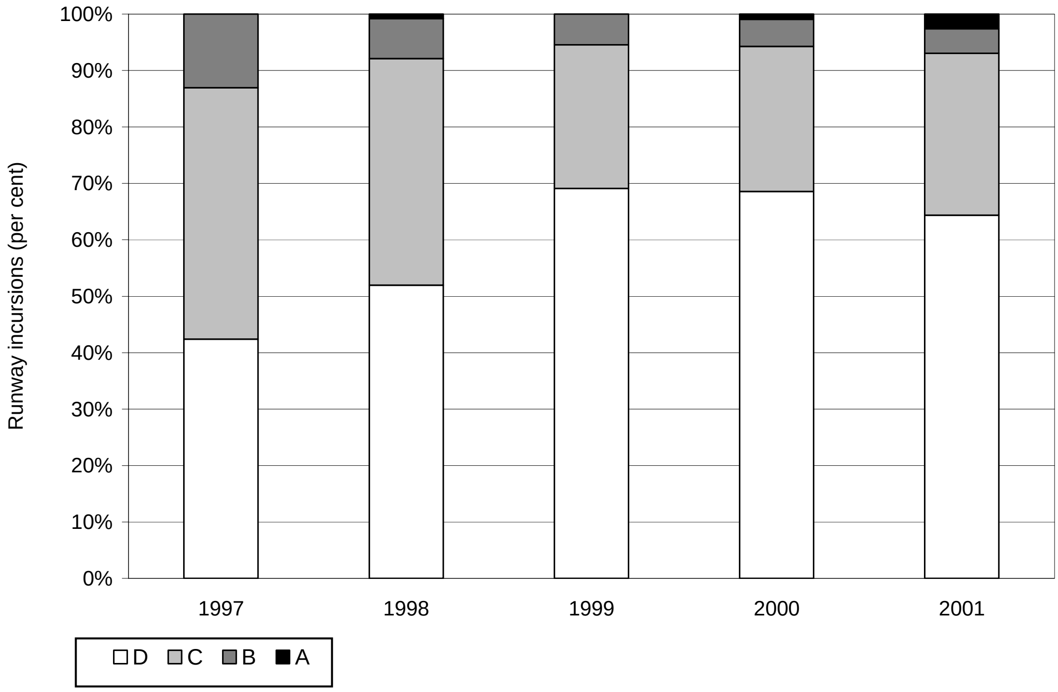


FIGURE 10:
Runway Incursion Severity Distribution- Australia 1997 to 2001



The US reported around five incursions for every one million operations over the period 1997 to 2000 (FAA Office of Runway Safety, 2002). Australia reported 34 incursions per million operations for the same period. These figures are well in excess of the US rate but are partially due to differing incursion definitions.

The definition of runway incursions adopted in the FAA report is less inclusive than that adopted in Australia. This effectively reduces the number of reportable incursions in the US when compared with Australia. The FAA definition requires two parties to be in conflict on a runway before an incursion is identified. This means that two objects, for example a vehicle and an aircraft, have to be present and in conflict on a runway. The Australian definition extends to occurrences that involve an unauthorised presence on a runway, regardless of a second conflicting party. Therefore, a direct comparison between US and Australian rates would be invalid. Instead, a comparison based on severity ratings was carried out. The analysis removed the lower level *d* incursions and concentrated on the higher severity levels (*a* ,*b* and *c*) to partially remove the effect of the definitional differences. Any interpretation of the results of such a comparison must bear these limitations in mind. It should also be noted that reporting tendencies will have an impact on the data and that it cannot be determined if reporting behaviours are the same for the two samples.

A comparison of the two countries was carried out using the data for 2000 and 2001 due to the instability of the distributions for the earlier years and figures are shown in table 7. As expected, Australia had higher incursions rates for severity level *d* events when compared with the US level *d* events (23 compared with 3.1 incursions per million operations respectively). The level *d* incursions were then removed from the Australian figures to make the samples more comparable. Even after the level *d* incursions were removed, Australia continued to have a higher rate of incursions than the US (12 compared with 6 incursions per million movements respectively).

TABLE 7:
Runway incursions by severity - Australia and United States 2000 to 2001

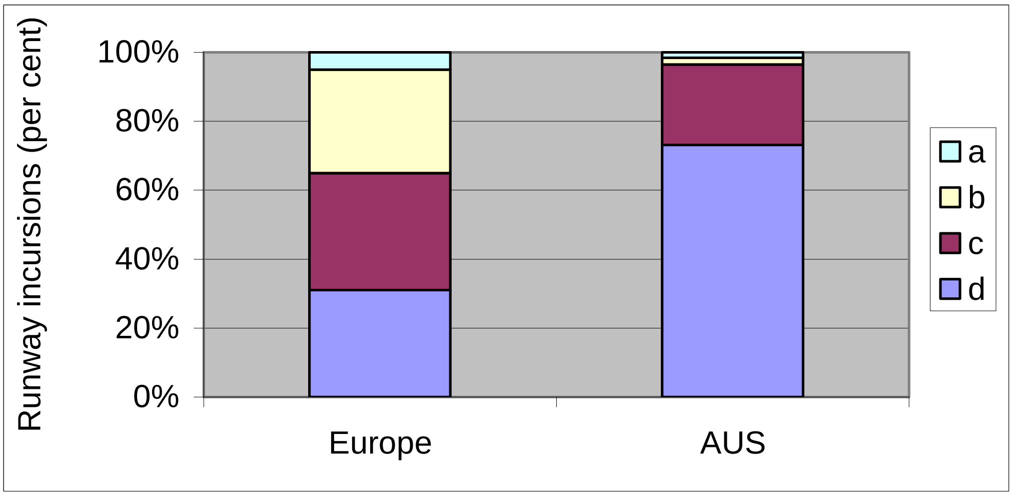
Australia, 2000-2001				*United States, 2000-2001*		
Level of Severity	*Incursions*	*%*	*Rate per million*	*Incursions*	*%*	*Rate per million*
d	146	66	23.0	418	51	3.1
c	60	27	9.7	276	34	2.0
b	10	5	1.6	80	10	0.6
a	4	2	0.6	39	5	0.3
Total	220	100	34.9	813	100	6.0

4.10 Comparison with European data

A Runway Safety Survey was also conducted by Eurocontrol, the European organisation for the safety of air navigation (Wilson, 2002). The study focused on nine European aerodromes and gathered data on runway incursions that occurred from 2000 to 2001. The definition adopted was similar to the Australian definition in that an object acting in an unauthorised manner could constitute an incursion (i.e. two objects were not necessary for an incursion to take place).

The European data were also classified using the definitions of severity supplied in the FAA report. The European and Australian results for 2000 to 2001 are shown in figure 11. Care must be taken with comparisons, as it cannot be assumed that reporting behaviours are the same for the two samples. A statistical comparison cannot be made using the data available, but a visual inspection implies than Australia recorded more low severity and far fewer high severity incursions than European aerodromes.

FIGURE 11:
Consequence Severity Ratings – Australia and Europe 2000 to 2001



DISCUSSION

The majority of runway incursions in Australia have a low potential to result in an accident. Australia has never experienced a large scale accident due to a runway incursion, but vigilance is required to maintain this safety record.

Data described and analysed in this report were sourced from the ATSB's OASIS database. The data have been reviewed and analysed to better understand runway incursions in Australia by way of addressing the following questions.

a) Have incursions increased or decreased?

Statistical tests revealed no significant differences in incursion rates across the years for the towered aerodrome groups studied, with the exception of a statistically significant increase in incursions for GAAP aerodromes in 2003 and a marginally significant increase for Class C aerodromes in 2003. More time is required to ascertain whether it is likely to become an ongoing trend; however, caution should be used in interpreting this result as changes in reporting rates or definitions can lead to distortion of the figures.

b) What are the main reasons for incursions?

The ATSB's review and analysis generally supported previous research about the causes of runway incursions. The data indicated that the large majority of incursions (79 per cent at Class C and D, 91 per cent at GAAP aerodromes) were due to communication problems between controllers and another party, usually pilots.

Aerodromes differ in their configuration complexity, traffic mix and volume, and in their use of capacity-enhancing procedures such as parallel runways. All these factors have been previously identified as contributing to runway incursions (Transport Canada, 2000). This report has not focused on causes at specific aerodromes, where factors combine in unique ways to increase the probability of runway incursions. However, the complexity of these factors should be remembered when considering the causes of runway incursions.

c) How does the rate of incursions in Australia compare with other countries?

Incursion rate comparisons
Although reports containing figures on runway incursions have been released by the United States, Canada and Europe, direct rate comparisons were not possible. This was due to methodological and definitional differences in the data. It was possible, however, to compare Australian data with United States and European data based on the severity of the occurrences.

Incursion severity comparison
The occurrences were classified into four levels of severity based on the definitions used in the FAA report on this topic. Low severity incursions were events that satisfied the definition of an incursion, but involved little or no risk of a collision; high severity incursions required immediate action to avoid an imminent collision.

Australia and the US experienced 92 per cent and 81 per cent of low severity 'level d' incursions, indicating that the majority of runway incursions were not likely to result in an accident. The data indicated that the Australian incursion rate was higher than the US rate, even when definitional differences were countered. The comparison with the European data was limited due to the assumptions being made, but suggested that Australia had more low severity and less high severity incidents than the European sample.

d) How significant is the risk to Australian aviation safety?

In 92 per cent of cases the severity was low, producing minimal accident potential to the aircraft involved. Runway incursions presented a serious accident potential in two out of every million operations.

Viewed in comparison with other reportable events, incursions were atypical events that rarely posed a serious accident risk. However, given the potential catastrophic consequences of incursions, it would not be prudent to become complacent about them. It should be remembered that at Class C and D aerodromes, high capacity RPT traffic and low capacity RPT traffic is involved in 31 per cent and 11 per cent of incursions respectively.

CONCLUSIONS

Australian incursion rates have remained stable indicating that incursions have neither improved nor worsened over the period studied. Comparisons between data from Australia and the United States indicate that Australia experienced twice as many runway incursions as the US, even when definitional differences are considered. Differences in reporting tendencies between the two countries may be influencing these results.

The data in both samples indicated that most incursions could best be described as low severity (level *d*) incursions. Of the incursions reported in Australia, only two in every million operations posed a severe risk of collision. While these results are encouraging, the problem of runway incursions still requires attention, particularly at aerodromes with elevated incursion rates.

Overall, the data confirm the need for constant vigilance and the implementation of all practicable measures for reducing runway incursions.

RECOMMENDED READING

FAA Office of Runway Safety. (2002). *FAA Runway safety report: runway incursion severity trends at towered aerodromes in the United States CY1998-CY2001.* www.faarsp.org/information.htm#1

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APPENDIX – NATIONAL DATA SET

TABLE A1:
Runway incursions, Australian Airports, 1997 to 2003

		Runway incursions (calendar year)						
Aerodrome classification	**Aerodrome**	***1997***	***1998***	***1999***	***2000***	***2001***	***2002***	***2003***
Class C	Adelaide	0	3	1	3	0	1	3
	Brisbane	3	5	3	2	2	4	6
	Cairns	11	11	7	8	10	6	3
	Canberra	7	4	4	4	8	7	8
	Coolangatta	0	0	0	2	0	0	0
	Darwin	4	7	12	6	8	9	23
	Melbourne	0	1	6	4	3	5	2
	Perth	1	4	5	3	3	1	2
	Sydney	19	23	15	15	16	8	18
	Townsville	1	1	0	3	2	0	5
	Total Class C	46	59	53	50	52	41	70
Class D	Albury	2	0	0	0	0	1	1
	Alice Springs	1	1	1	3	2	0	2
	Coffs Harbour	4	3	1	0	1	3	2
	Hobart	0	1	0	0	0	2	1
	Launceston	1	0	0	0	0	0	0
	Mackay	3	2	8	0	3	2	1
	Sunshine Coast/ Maroochydore	1	2	0	0	0	0	1
	Rockhampton	2	0	1	0	1	4	4
	Tamworth	2	1	2	1	2	3	2
	Total Class D	16	10	13	4	9	15	14
GAAP	Archerfield	1	2	1	7	1	2	1
	Bankstown	13	51	24	36	42	33	40
	Camden	1	0	0	0	2	4	3
	Essendon	7	2	6	5	3	6	9
	Jandakot	5	0	2	4	3	4	6
	Moorabbin	9	4	2	0	1	1	5
	Parafield	1	4	13	2	3	3	4
	Total GAAP	37	63	48	54	55	53	68
Military	Amberley, Aerodrome	0	0	0	1	0	0	0
	Nowra, Aerodrome	0	1	1	8	2	2	1
	Oakey, Aerodrome	0	0	0	1	0	2	1
	Pearce, Aerodrome	1	0	0	0	0	0	0
	Richmond, Aerodrome	0	0	0	1	0	0	0
	Tindal, Aerodrome	0	0	0	0	0	0	3
	Williamtown, Aerodrome	0	0	0	1	0	1	0
	Total	1	1	1	12	2	5	5

Source: Australian Transport Safety Bureau

TABLE A2:
Aircraft movements, Australian airports, 1997 to 2003

		Aircraft movements (calendar year)						
Aerodrome classification	**Aerodrome**	***1997***	***1998***	***1999***	***2000***	***2001***	***2002***	***2003***
Class C	Adelaide	110,736	115,113	112,766	112,554	111,186	103,526	101,420
	Brisbane	164,134	160,983	160,344	169,198	172,104	145,870	139,812
	Cairns	109,672	108,973	106,384	106,622	103,356	101,920	102,542
	Canberra	133,216	134,496	131,798	129,370	115,962	85,892	87,450
	Coolangatta	94,290	84,798	90,042	89,188	84,286	81,958	87,414
	Darwin[1]		48,088	94,598	97,796	89,924	78,476	74,434
	Melbourne	154,086	156,102	159,582	174,462	177,588	155,546	158,584
	Perth	109,414	104,820	102,996	103,198	96,396	91,878	93,950
	Sydney	279,694	281,841	284,626	308,342	296,642	252,504	258,206
	Townsville[1]		38,932	69,528	69,638	65,564	54,294	52,674
	Total Class C	1,155,242	1,234,146	1,312,664	1,360,368	1,313,008	1,151,864	1,156,486
Class D	Albury	48,824	39,159	37,376	34,274	30,068	29,678	31,024
	Alice Springs	35,492	31,993	31,196	32,728	30,984	25,672	26,012
	Coffs Harbour	40,814	37,136	11,804	38,916	41,320	37,390	30,588
	Hobart	47,730	29,630	11,726	15,762	19,208	21,286	30,242
	Launceston	33,492	30,890	25,138	26,384	23,212	19,196	18,128
	Mackay	44,486	41,358	40,948	38,720	36,506	37,316	37,902
	Sunshine Coast/ Maroochydore	95,533	88,995	80,368	83,814	61,074	73,458	58,982
	Rockhampton	35,448	32,847	32,730	34,868	36,504	34,976	33,522
	Tamworth	99,951	96,373	98,744	118,602	104,060	94,418	93,118
	Total Class D	481,770	428,381	370,030	424,068	382,936	373,390	359,518
GAAP	Archerfield	250,592	195,986	165,090	182,682	175,704	135,666	132,250
	Bankstown	405,489	310,614	298,006	298,798	331,420	345,268	296,398
	Camden	122,066	92,321	83,676	83,120	73,636	61,780	46,264
	Essendon	68,899	73,062	70,210	66,940	67,538	68,418	64,240
	Jandakot	426,226	323,951	254,104	265,700	302,884	314,734	324,462
	Moorabbin	362,220	290,985	259,126	256,644	253,700	253,102	235,678
	Parafield	275,772	183,068	121,026	158,268	174,588	143,080	128,180
	Total GAAP	1,911,264	1,469,987	1,251,238	1,312,152	1,379,470	1,322,048	1,227,472

[1] No aircraft movement data is available for 1997. 1998 figures are the number of movements for July to December only.

TABLE A3:
Runway incursion incidents per million aircraft movements, Australian airports, 2001 to 2003

		Runway incursions per million aircraft movements							
Aerodrome classification	**Aerodrome**	***1997***	***1998***	***1999***	***2000***	***2001***	***2002***	***2003***	***Total[2]***
Class C	Adelaide	0	26	9	27	0	10	30	14
	Brisbane	18	31	19	12	12	27	43	22
	Cairns	100	101	66	75	97	59	29	76
	Canberra	53	30	30	31	69	81	91	51
	Coolangatta	0	0	0	22	0	0	0	3
	Darwin[2]	-	62	127	61	89	115	309	143
	Melbourne	0	6	38	23	17	32	13	18
	Perth	9	38	49	29	31	11	21	27
	Sydney	68	82	53	49	54	32	70	58
	Townsville[2]	-	26	0	43	31	0	95	34
	Total Class C[2]	35	45	40	37	40	36	61	43
Class D	Albury	41	0	0	0	0	34	32	16
	Alice Springs	28	31	32	92	65	0	77	47
	Coffs Harbour	98	81	85	0	24	80	65	59
	Hobart	0	34	0	0	0	94	33	23
	Launceston	30	0	0	0	0	0	0	6
	Mackay	67	48	195	0	82	54	26	69
	Sunshine Coast/ Maroochydore	10	22	0	0	0	0	17	7
	Rockhampton	56	0	31	0	27	114	119	50
	Tamworth	20	10	20	8	19	32	21	18
	Total Class D	33	23	35	9	24	40	39	29
GAAP	Archerfield	4	10	6	38	6	15	8	12
	Bankstown	32	164	81	120	127	96	135	105
	Camden	8	0	0	0	27	65	65	18
	Essendon	102	27	85	75	44	88	140	79
	Jandakot	12	0	8	15	10	13	18	11
	Moorabbin	25	14	8	0	4	4	21	12
	Parafield	4	22	107	13	17	21	31	25
	Total GAAP	19	43	38	41	40	40	55	38

[2] Incursions occurring at Townsville and Darwin airport occurring between January 1997 and June 1998 were excluded from the calculation of rates due to movement data being unavailable.

Runway Incursions: 1997 to 2003

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