Australian Government

Australian Transport Safety Bureau

ATSB TRANSPORT SAFETY INVESTIGATION REPORT

Aviation Research and Analysis Report – B20070107

Final

Trends in immediately reportable matters involving regular public transport operations

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Trends in immediately reportable matters involving regular public transport operations

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Abstract

The reporting of aviation safety occurrences enables the Australian Transport Safety Bureau (ATSB) to investigate accidents and serious incidents and monitor safety through the analysis of any trends. On 1 July 2003 the *Transport Safety Investigation Act 2003* came into effect, introducing the terms immediately reportable and routine reportable matters (IRMs and RRMs, respectively).

This report examines trends in IRMs that involved regular public transport operations and provides a context for interpreting any changes over time. The aim is to inform the aviation community of any important safety trends, and to provide the travelling public with a better appreciation of the types of occurrences that are reported to the ATSB.

The study found that high capacity regular public transport operations dominated air transport activity, and consequently dominated the reports of IRM occurrences. Furthermore, activity for high capacity air transport operations, measured by flying hours and movements, increased over the period studied.

The IRM categories examined were either stable or trended downwards between mid 2001 and mid 2006. Violations of controlled airspace reduced over the period while occurrences involving a fire, explosion or fumes and crew injuries or incapacitation also decreased, but only marginally. Other IRM categories such as uncontained engine failures and fuel exhaustion events were rare, or absent. The exception was breakdowns of separation (BOS) and airprox events, where occurrence numbers went up. However, the rate did not increase relative to the number of movements, suggesting that the increase was largely linked to increased activity.

This review highlighted the consistent reporting culture of the air transport sector and the air traffic service provider, and provided encouraging data concerning the general state of safety in regular public transport operations.

THE AUSTRALIAN TRANSPORT SAFETY BUREAU

The Australian Transport Safety Bureau (ATSB) is an operationally independent multi-modal Bureau within the Australian Government Department of Transport and Regional Services. ATSB investigations are independent of regulatory, operator or other external bodies.

The ATSB is responsible for investigating accidents and other transport safety matters involving civil aviation, marine and rail operations in Australia that fall within Commonwealth jurisdiction, as well as participating in overseas investigations involving Australian registered aircraft and ships. A primary concern is the safety of commercial transport, with particular regard to fare-paying passenger operations.

The ATSB performs its functions in accordance with the provisions of the *Transport Safety Investigation Act 2003* and Regulations and, where applicable, relevant international agreements. The object of a safety investigation is to determine the circumstances to prevent other similar events. The results of these determinations form the basis for safety action, including recommendations where necessary. As with equivalent overseas organisations, the ATSB has no power to implement its recommendations.

It is not the object of an investigation to determine blame or liability. However, it should be recognised that an investigation report must include factual material of sufficient weight to support the analysis and findings. That material will at times contain information reflecting on the performance of individuals and organisations, and how their actions may have contributed to the outcomes of the matter under investigation. At all times the ATSB endeavours to balance the use of material that could imply adverse comment with the need to properly explain what happened, and why, in a fair and unbiased manner.

Central to the ATSB's investigation of transport safety matters is the early identification of safety issues in the transport environment. While the Bureau issues recommendations to regulatory authorities, industry, or other agencies in order to address safety issues, its preference is for organisations to make safety enhancements during the course of an investigation. The bureau is pleased to report positive safety action in its final reports rather than make formal recommendations. Recommendations may be issued in conjunction with ATSB reports or independently. A safety issue may lead to a number of similar recommendations, each issued to a different agency.

The ATSB does not have the resources to carry out a full cost-benefit analysis of each safety recommendation. The cost of a recommendation must be balanced against its benefits to safety, and transport safety involves the whole community. Such analysis is a matter for the body to which the recommendation is addressed (for example, the relevant regulatory authority in aviation, marine or rail in consultation with the industry).

EXECUTIVE SUMMARY

Background and objectives

Aviation occurrence (accident and incident) reports assist the Australian Transport Safety Bureau (ATSB) to conduct investigations and monitor safety. Reporting obligations changed on 1 July 2003 with the introduction of the *Transport Safety Investigation Act 2003* (TSI Act) and Transport Safety Investigation Regulations 2003 (TSI Regulations). For the first time, specific occurrences that need to be reported were prescribed. These occurrence types are referred to as reportable matters, and are defined as either immediately reportable or routine reportable, depending upon the seriousness of the event and the category of operation.

Since the introduction of the TSI Act, the number of occurrence notifications to the ATSB has increased significantly. As a first step towards understanding the factors that may have led to the increased reporting, the ATSB examined the trends in immediately reportable matters (IRMs) for high and low capacity air transport operations.[1]

The aim is to inform the aviation community of any important safety trends, and to provide the travelling public with a better appreciation of the types of occurrences that are reported to the ATSB.

The IRM categories reviewed in this study include: accidents; violations of controlled airspace; breakdowns of separation and airproxes; fire, smoke, explosions or fumes; crew injury or incapacitation; fuel exhaustion; and uncontained engine failures. The study examined the period commencing in mid 2001 – before the introduction of the TSI Act, as many of the IRMs prescribed were also normally reported to the ATSB under Part 2A of the *Air Navigation Act 1920* (AN Act) – and mid 2006. This permitted analysis to consider trends over a longer period, and to consider whether changes in the number of occurrences reported to the ATSB were influenced by the introduction of the TSI Act and Regulations.

Analysis and results

The primary findings, also summarised in Figure 1, are presented below.

Overall

- The activity data demonstrated growth in the regular public transport (RPT) industry, due entirely to a growth in high capacity operations since mid 2002. Very few accidents occurred in RPT airline operations.

Violations of controlled airspace (VCAs)

- A downward trend in VCAs was observed.

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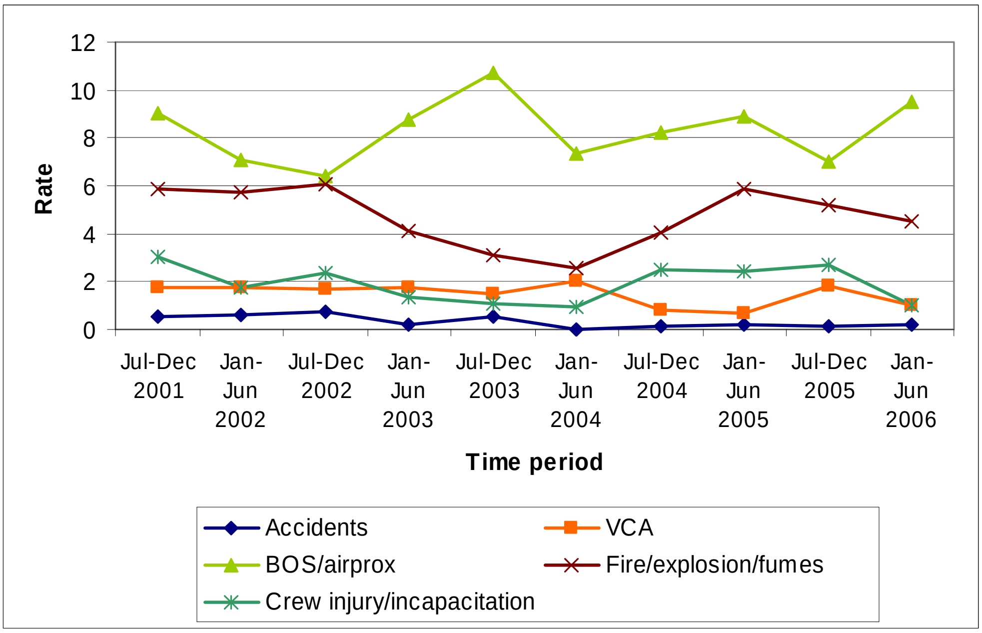
1 High capacity means the aircraft's certificate of type approval permits a maximum seating capacity of more than 38 seats or a maximum payload of more than 4,200kg (Civil Aviation Order (CAO) 82.0 s. 2). Low capacity refers to aircraft used in regular public transport operations other than high capacity aircraft.

Air transport, as defined in the TSI Act, refers to high and low capacity regular public transport and charter operations. This report concentrates on regular public transport operations only.

- Low capacity RPT operations were involved in the same number of VCA events as high capacity RPT operations, yet flew substantially fewer hours.
- The most common type of airspace violation, by both high capacity and low capacity RPT operations involved controlled airspace, with restricted airspace the next most common.
- Ninety per cent of VCA occurrences were due to crew actions. For low capacity operations, the crew failed to request a clearance in 70 per cent of occurrences. The high capacity operations were evenly spread between failure to request a clearance, failure to comply with an air traffic control (ATC) instruction, and diversion due to weather.

Figure 1: Summary of rates per 100,000 aircraft movements for each IRM group, 1 July 2001 to 30 June 2006



Breakdown of separation (BOS) and airprox

- The actual number of BOS and airprox events increased, but the rate for these occurrences was steady over the period studied.
- The trend in BOS/airprox events differed between low capacity and high capacity RPT operations. The number of BOS increased in high capacity operations but decreased in low capacity operations. The number of low capacity airproxes remained stable. Unsurprisingly, airprox events involving high capacity operations were rare.
- The contributory factors for BOS events were analysed. In high capacity operations the BOS was attributed to ATC procedures in 54 per cent of occurrences and to crew actions in 44 per cent of occurrences. The remaining 2 per cent involved either vehicle incursions or were unknown. In low capacity operations 51 per cent of occurrences were attributed to crew actions and 48 per cent to ATC procedures. The most common crew actions were ‘altitude busts’ and VCAs. There was one occurrence involving a runway incursion by a vehicle.

- The most common recovery measure for BOS events was ATC detecting and correcting the conflict.

Fire, smoke, explosion or fumes

- Fifty three per cent of these occurrences involved fumes, 37 per cent involved smoke and 8 per cent involved fire. There were no expected explosions in the 5-year period.
- The rate of reported fire, explosion or fumes decreased slightly over the period studied.
- The vast majority of occurrences resulted in nil (97 per cent) or minor (2 per cent) injuries.

Crew injury or incapacitation

- A small downward trend in the rate of crew injury and incapacitation was observed.
- Seventy four per cent of such occurrences involved injury or incapacitation of cabin crew, and 24 per cent of occurrences involved the flight crew. Cabin crew were usually injured as a result of sudden aircraft movements such as turbulence, while the flight crew typically suffered from acute illness.
- The level of injury or illness was generally minor.

Conclusions

Despite the increased activity in scheduled public transport operations, the number of IRM occurrences has generally either remained stable or declined. When measured in relation to airline activity, the trend rate is generally downwards. There was no evidence of a change in the reporting culture of IRMs as a result of the introduction of the TSI Act, probably because an effective reporting culture for airlines and the air traffic service provider already existed.

ABBREVIATIONS

AIRPROX	Airprox is the combination of the two words, air and proximity. Airprox is defined as an occurrence in which two or more aircraft come into such close proximity that a threat to the safety of the aircraft exists or may exist, in airspace where the aircraft are not subject to an air traffic separation standard, or where separation is a pilot responsibility.
AN	Air Navigation
ATSB	Australian Transport Safety Bureau
ATC	Air traffic control
ATS	Air traffic services
BOS	Breakdown of separation
CAAP	Civil Aviation Advisory Publication
CAO	Civil Aviation Order
CAR	Civil Aviation Regulations
CTA	Control area that is not a control zone
CTAF	Common traffic advisory frequency area
CTR	Control zone
ESIR	Electronic Safety Incident Reporting System
FL	Flight level
FT	Feet
ICAO	International Civil Aviation Organization
IFR	Instrument flight rules
IRM	Immediately reportable matter
Kts	Knots
MBZ	Mandatory broadcast zone
NAS	National Airspace System
NM	Nautical miles (1 NM = 1.85 kilometres)
NOTAM	Notice to airmen
OCTA	Outside controlled airspace
PIC	Pilot in command
PRD	Prohibited, restricted, danger
RAAF	Royal Australian Air Force

RNAV (GNSS)	Area navigation global navigation satellite system
RPT	Regular public transport
RRM	Routine reportable matter
RVSM	Reduced vertical separation minima
SARS	Severe acute respiratory syndrome
SMC	Surface movement controller
TAAATS	The Advanced Australian Air Traffic System
TCAS	Traffic alert and collision avoidance system
TSI	Transport Safety Investigation
VCA	Violation of controlled airspace
VFR	Visual flight rules
VOR	Very high frequency omni-directional radio range

1 INTRODUCTION

1.1 Background

The Australian Transport Safety Bureau (ATSB) investigates selected accidents, serious incidents and incidents in response to reports of aviation occurrences. The ATSB also monitors safety through the analysis of data to determine whether important trends are emerging. Reporting obligations for the aviation industry changed in mid 2003 with the introduction of the *Transport Safety Investigation Act 2003* (TSI Act) and Transport Safety Investigation Regulations 2003 (TSI Regulations). The TSI Regulations prescribe which types of occurrence need to be reported to the bureau. These occurrence types are now referred to as reportable matters.

This report examines the generally more serious immediately reportable matters (see 1.2.2) for the purpose of identifying any trends in these occurrence types, and provides a context for interpreting any changes over time. The aim is to inform the aviation community of any important safety trends, and to provide the travelling public with a better appreciation of the types of occurrences that are reported to the ATSB. In doing so, this report provides information to better understand immediately reportable matters.

1.2 Reporting to the ATSB

1.2.1 Air Navigation Act 1920

Prior to 1 July 2003, occurrence information was collected by the ATSB under the authority of Part 2A of the *Air Navigation Act 1920* (AN Act). This Act required the reporting of accidents, serious incidents and incidents involving Australian registered aircraft, or foreign registered aircraft in Australian territory.

An accident was defined as the death or serious injury of a person, as a result of the operation of the aircraft, between the time the person boards the aircraft with the intention of flight until they disembark. The death or injury could also be the result of coming into contact with the aircraft or part of the aircraft, attached or detached. The definition of an accident also included missing aircraft or where the aircraft was damaged, structurally compromised or the performance/flight characteristics of the aircraft was affected or believed to be affected.

The definition of an accident excluded death or serious injury resulting from natural causes, self inflicted injury or injury caused by the action of a person performing activities not associated with the operation of the aircraft.

A serious incident was defined as an occurrence associated with the operation of an aircraft that affected or could have affected the safety of the operation of the aircraft or indicated that an accident nearly occurred.

An incident was defined as an occurrence, other than an accident or serious incident, associated with the operation of an aircraft that affected or could have affected the safety of the operation of the aircraft or another aircraft.

These definitions of accident, serious incident and incident were broad and lacked clear boundaries separating each type of occurrence. In addition, there was little supporting information to help the aviation community distinguish which category a particular occurrence might belong to, and often required some interpretation by the person reporting the occurrence.

1.2.2 Transport Safety Investigation Act 2003

In July 2003 the TSI Act replaced Part 2A of the Air Navigation Act. The TSI Act enables independent, no blame safety investigations by the ATSB in the aviation, marine and rail modes of transport. The Act also prescribes the kinds of aviation occurrences that must be reported to the ATSB in more detail than was the case with the AN Act. These occurrences are categorised as either immediately reportable matters, or routine reportable matters. This data can be used to examine trends and assist the bureau assess the overall level of safety. Reporting obligations for air transport operations are given special attention, reflecting the priority afforded to a safe air transport system for the public.

Occurrence reporting to the ATSB

The ATSB received approximately 12,500 occurrence reports in the financial year 2005-06. These reports were received via fax, phone, mail, email, web-based forms, and from Airservices Australia’s Electronic Safety Incident Reporting system (ESIR). Airservices Australia, the largest single source of notifications, accounted for around half of all notifications received by the ATSB.

There was a considerable jump in the number of reports received by the ATSB between financial year 2003-04 and 2004-05, when the total number of reports grew from around 8,500 to 12,300. They have increased further over the subsequent two years, to around 13,000 notifications. This increase in reporting, for all aviation sectors and operator types, followed the introduction of the TSI Act and led to speculation about the influence of the Act on reporting to the ATSB. An analysis of the source of notifications shows that the increase since 2004-05 was driven by increases in both the reports received via email and from Airservices Australia through its ESIR system. The increased email reporting appears to be a consequence of notifications being facilitated by electronic communication. A similar increase occurred in 1998 when Airservices Australia implemented its ESIR system. Adding to the overall increase appears to be a decision by Airservices Australia for its staff to report all matters that come to their attention. Around a half of all Airservices notifications represent a reportable matter as defined in the TSI Regulations.

Not all of the reports received by the bureau met the criteria of an immediately reportable or routine reportable matter, and many of the reports were duplicates for the same event. Hence not all occurrence reports received were included into the ATSB occurrence database as an accident, serious incident or incident. Of the 12,500 occurrences notified to the ATSB in 2005-06, only 7,471 were entered into the ATSB database as reportable occurrences, although this is higher than the number of reportable occurrences recorded in previous years (Australian Transport Safety Bureau, 2006). This is because the ATSB changed the way it classified certain events, treating some events as reportable matters that were not previously recorded this way. For example, from 1 July 2005, violations of controlled airspace by general aviation aircraft were entered into the ATSB database as reportable occurrences, although these events are not required to be reported under the TSI Regulations. That change in policy meant that nearly 1,200 more reportable occurrences were captured by the ATSB than for 2004-05, which accounts for around 85 per cent of the increase in reportable matters recorded.

Overall, around 27 per cent of all event notifications received by the ATSB fall outside the scope of the Regulations, and a further 15 per cent are duplicate reports. Duplicate reporting is especially common for bird strike events (a routine reportable matter for air transport operations) where any of several directly involved parties (air traffic control, the airport operator, or the airline) might lodge a report for the same occurrence.

Reportable matters

Reportable matters are comprised of both immediately reportable matters (IRMs) and routine reportable matters (RRMs). An immediately reportable matter is equivalent to an accident or serious incident under the AN Act, while a routine reportable matter is equivalent to an incident.

The terms immediately reportable and routine reportable matters replaced the terms accident, serious incident and incident to ensure the terminology used in the Act could accommodate the ATSB's responsibilities for multi-modal transport investigations.

Immediately reportable matters must be reported as soon as reasonably practicable by telephone, and a written report must be provided within 72 hours. Routine reportable matters only require a written report to be lodged with the ATSB within 72 hours of the occurrence.

The category of reportable matters differs depending on the type of flying operation. There are lists of reportable matters that apply to 1) all aircraft operations, 2) for aircraft involved in air transport[2] operations and 3) for aircraft involved in operations other than air transport. The IRM and RRM lists for all aircraft operations and for aircraft involved in air transport current from 1 July 2003 are included at Appendix A.[3]

Immediately reportable matters

Many types of IRM are rare, and so this report focuses on the more common occurrences and identifies whether any trends are apparent. This section describes each of the IRM examined in this report.

Accidents

Reportable accidents, consistent with the internationally agreed definition, involve the death or serious injury of a person on board the aircraft or in contact with the aircraft, or anything attached to or detached from the aircraft. Injuries resulting from natural causes, self harm, intentional injury from another person or that result in the death of the person after 30 days of the aviation occurrence are excluded.

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2 An air transport operation is a regular public transport operation or a charter operation.

3 At the time this report was drafted, the ATSB was working on some proposed fine tuning of the reporting regulations.

Accidents also include missing aircraft, the aircraft suffering serious damage or believed to have been damaged, the aircraft being inaccessible and the existence of reasonable grounds for believing that the aircraft has been seriously damaged.

Violation of controlled airspace

Civil airspace in Australia is broadly divided into two categories, controlled and uncontrolled. The airspace category is determined by the density and complexity of the air traffic in that area (Airservices Australia, 2003). In controlled airspace air traffic services separate aircraft and manage the flow of traffic while in uncontrolled airspace pilots are responsible for separation and traffic flow. Some airspace is also classified as prohibited, restricted or danger (PRD) areas. Danger areas identify potential hazards (for example, the location of parachuting operations), but entry into this airspace does not require a clearance. Flight in prohibited areas is not permitted under any circumstances, while flight in restricted areas may be permitted and a clearance is required prior to entry. Many restricted areas are associated with military operations (for example some military control zones and training areas around Defence facilities), although non-military airspace can also be designated a restricted area, for example the airspace around the Lucas Heights nuclear reactor. Prohibited, restricted or danger areas can be permanently activated, activated routinely at specified times, or activated temporarily by a notice to airmen (NOTAM). The only prohibited airspace in Australia is associated with the Joint Defence Facility at Pine Gap (Airservices Australia, 2007).

The two categories of civil airspace are further divided into classes with different levels of control and separation. Controlled airspace is comprised of Class A, Class C, Class D or Class E. Class A airspace includes oceanic and high level airspace over mainland Australia. Class C includes high level airspace over mainland Australia and in steps around major capital cities and other major airports. Class D airspace is located in and around designated secondary and regional aerodromes. Class E is mid-level airspace along the east coast excluding the area over major aerodromes. Class G is uncontrolled airspace (Airservices Australia, 2003).

There are entry requirements for each of the classes of controlled airspace. The entry requirement is called an air traffic control (ATC) clearance, which is an authorisation for an aircraft to proceed along a specified track, at a certain level and speed and complying with any other specified directions. The purpose of a clearance is to regulate traffic and minimise the risk of conflicts between aircraft (Airservices Australia, 2003). Clearances are required for all aircraft flying under instrument flight rules (IFR) to enter Class A, C, D and E and a clearance for aircraft flying under visual flight rules (VFR) to enter class C or D (Airservices Australia, 2007).

A violation of controlled airspace is the unauthorised entry of an aircraft into airspace for which a clearance is required or to which entry is prohibited. For IFR flight this means Class A, C, D or E and for VFR flight, Class C or D. Entry into any restricted area without a clearance is also recorded as a violation of controlled airspace.

Breakdown of separation and airprox

Separation standards are applied in Australian airspace to keep aircraft at a specified distance from other aircraft thus reducing the risk of a midair collision. Any two aircraft must always be separated by at least one prescribed standard when operating in controlled airspace, although more than one standard can be in place at the same time (Airservices Australia, 2003).The type of standard in place is decided by ATC and is selected on the environment and circumstances at the time (Airservices Australia, 2003).

Not all aircraft are separated by ATC. The type of air traffic service, including the type of separation service, varies with the class of airspace and flight rules the aircraft is operating under. The majority of regular public transport flights operate under IFR and thus receive separation services from ATC when flying in Class A,C, D or E airspace.

Separation can be achieved laterally, vertically and or longitudinally. Vertical separation is the minimum vertical distance between two aircraft and is governed by several factors including flight rules, altitude or reduced vertical separation minima[4] (Airservices Australia, 2003). Vertical separation means that aircraft would not generally come closer than 1,000 ft.

Lateral separation is the minimum distance between aircraft in the lateral plane. It is based on the 'possible position' of the aircraft derived from either internal navigation sources, radio navigation aids or dead reckoning, taking into account the accuracy of the navigational equipment being used. 'The possible position' of each aircraft is then used to keep the aircraft a specified number (usually one) nautical miles apart (Airservices Australia, 2003).

Longitudinal separation is applied between aircraft travelling on the same or reciprocal direction tracks[5] and is based on either time or distance (Airservices Australia, 2003).

Vertical, lateral and longitudinal separation can vary depending upon whether ATC are applying procedural or radar separation standards. Radar separation involves a controller observing the representation of radar returns from two (or more) aircraft to ensure they are provided adequate separation. Procedural separation involves using radio reports, from the pilot, of the aircraft's position to keep aircraft separated and therefore involves applying greater distances between aircraft (ICAO, 2001).

Outside controlled airspace, pilots are responsible for their own separation and rely on the see and avoid method, utilising radio transmissions as well as various traffic information services to aid situational awareness (Airservices Australia, 2003). It is also possible for ATC to assign the responsibility for separation to the pilot inside controlled airspace, where the pilot in command must sight and follow or see and avoid other aircraft.

In the context of this background information, the TSI Act defines a breakdown of separation as a failure to maintain a recognised separation standard (vertical, lateral or longitudinal) between aircraft that are being provided with an air traffic service separation service. The failure to maintain a separation standard may result from ATC, pilot, or other actions, and may occur even if only one of the aircraft involved

4 Reduced vertical separation minima (RVSM) applies to aircraft equipped with modern altimeter and auto-pilot systems. In Australia RVSM can be applied in controlled airspace and is applicable in most of our uncontrolled airspace. Reduced vertical separation minima permits aircraft to operate safely with reduced vertical separation.

5 Same or reciprocal direction tracks intercept at less than 45 degrees (Airservices Australia & Department of Defence, 2007).

is under control of ATC. For air transport aircraft, a separation standard is provided in controlled airspace at least between IFR aircraft.

An airprox is defined in the TSI Act as an occurrence in which two or more aircraft come into such close proximity that a threat to the safety of the aircraft exists or may exist, in airspace where the aircraft are not subject to an air traffic separation standard, or where separation is a pilot responsibility. Generally airprox events occur outside controlled airspace, but may also occur in controlled airspace if the pilot has accepted responsibility for maintaining separation.

Fire, smoke, explosion or fumes

The fire, smoke, explosion or fumes category covers any occurrence that involved at least one of these events, in any part of the aircraft, between the aircraft being prepared for take-off and disembarking. A fire or an explosion in an aircraft poses a serious risk to the lives of crew and passengers and in most circumstances requires the landing of an aircraft as soon as practicable. Fumes can indicate a problem with the design, manufacture or maintenance of an aircraft, or as a consequence of a problem on board an aircraft and may lead to the incapacitation of crew or passengers.

Crew injury or incapacitation

Crew injury or incapacitation refers to both flight and cabin crew. Since each member of the crew has a specific function to perform, the incapacitation of any member may affect the safe operation of the flight. For example if a cabin crew member is incapacitated the ratio of crew to passengers will affect the implementation of any emergency procedures.

Uncontained engine failure

An uncontained engine failure is defined as the disintegration or partial disintegration of an engine where the fragments exit through the side of the engine nacelle (external shell of the engine). Detached engine fragments exiting through the front or rear of the engine cowling is considered a contained engine failure.

Fuel exhaustion

The TSI Act states that fuel exhaustion refers to when an aircraft has exhausted its useable fuel.

The regulations specify that a flight should not commence unless the aircraft is carrying a sufficient quantity of fuel and oil to complete the flight safely (see Civil Aviation Regulation (CAR) r. 234). The regulations also stipulate that the calculations for the required fuel quantity consider not only the distance between departure, destination and alternate aerodromes, the fixed fuel reserve, as well as any taxi or manoeuvring requirements but also any in-flight variations due to ATC requirements, significant weather en-route and in-flight emergencies (see Civil Aviation Advisory Publication (CAAP) 234-1(1) and CAR r. 239).

1.3 Changes in the aviation environment

In addition to the change in legislation covering the investigation and reporting of aviation safety occurrences, the aviation environment in Australia also underwent a number of significant changes during the time period considered in this report.

There were a number of airline and fleet changes, significant changes to airspace design, and some changes in air transport activity as a result of the terrorist attacks in the United States on 11 September 2001, and the severe acute respiratory syndrome (SARS) virus in early 2003.

Also in September 2001, Ansett Australia, one of Australia's two major airlines, collapsed. This reduced the number of hours flown domestically for that year.

The impact of the collapse of Ansett on Australia's airline industry was mitigated by the expansion of Virgin Blue, which commenced domestic operations in August 2000, and the expansion of the Qantas fleet (Australian Transport Safety Bureau, 2007a). In May 2004 Jetstar commenced operations, further increasing the capacity of Australia's air transport sector.

The high capacity airline fleet, over the period of interest, has modernised with a reduction in the average age of medium sized, multi-engine aircraft (i.e. aircraft with a maximum takeoff weight between 50,000 and 100,000kg). This has not been the case across all airlines with the average age of aircraft used by regional airlines increasing (Australian Transport Safety Bureau, 2007b). The modernisation of a portion of the fleet has been accompanied by new aircraft avionics such as advanced navigation and collision avoidance systems.

Australian airspace has undergone a significant reform process between 2002 and the end of 2005. The model of reform that has been implemented is called the National Airspace System (NAS) (Department of Transport and Regional Services, 2007a, 2007b). The introduction of NAS reforms has occurred as a phased approach with Stage 1 implemented in November 2002 and Stages 1a, 2a, 2b and 2c implemented in March 2003, July 2003, November 2003 and November 2005 respectively (Department of Transport and Regional Services, 2005, 2007a). The Department of Transport and Regional Services identified the following key changes introduced by NAS:

- some uncontrolled airspace (Class G) became controlled airspace Class E;
- improved services for VFR aircraft in radar Class G and E airspace, for example access to radar based information services;
- lowering the base of Class A airspace to 18,000 ft in areas with radar coverage;
- proportion of en-route Class C airspace was changed to Class E;
- mandatory transponder carriage expanded to include all aircraft operating above 10,000 ft; and
- standardised operating procedures were introduced at all non-towered aerodromes (Department of Transport and Regional Services, 2007a).

Relevant to this report are the changes in airspace classification and subsequent changes in ATC services and separation standards that were affected by the change in airspace classification. With the introduction of NAS stage 2b, some of en-route Class C airspace was changed to Class E airspace. In addition, the airspace beneath Class E base, previously Class C, was replaced by Class E steps joining Class D tower airspace. The type of air traffic services provided and requirement to obtain a clearance for Class C and E airspace differ, especially for aircraft flying VFR. Given these differences in separation services and entry requirements between Class C and E airspace, the introduction of this stage had the potential to influence the incidence of BOS/airprox and violations of controlled airspace.

1.4 Report objective

This report reviews trends in immediately reportable matters for regular public transport operations. The IRM categories reviewed include: accidents; violations of controlled airspace; breakdowns of separation and airproxes; fire, smoke, explosions or fumes; crew injury or incapacitation; fuel exhaustion; and uncontained engine failures. The study reviewed occurrences that occurred between mid 2001 and mid 2006. The period studied begins before the introduction of the TSI Act, as the selected occurrences were also previously reported under the AN Act. This permits the report to consider trends over a longer period, and to consider whether changes in the number of occurrences reported to the ATSB were influenced by the introduction of the TSI Act.

2 METHODOLOGY

2.1 Data sources

This study is based on analysis of incidents reported to the ATSB for the 5-year period 1 July 2001 to 30 June 2006. A set of indicators of immediately reportable matters have been analysed over the defined period to identify any observable trends. A list of definitions for each of these occurrence types can be found in 1.2.2.

The data was divided into 6-month periods to allow for an assessment of the introduction of the TSI Act on the reporting of IRM and their equivalent prior to July 2003.

Accident and incident data

The data was sourced from the ATSB aviation occurrence database (OASIS) where occurrences reported to the ATSB are recorded. The extracted data included accidents or incidents that occurred over Australian territory and involved either VH-registered or foreign registered aircraft involved in regular public transport (RPT) operations. Air transport operations, as defined by the TSI Regulations, includes RPT and charter operations. This paper considers only those IRMs associated with RPT operations.

Since the aviation occurrence database is a live database the figures detailed in this report may vary from previously published data as a consequence of new information, or a change in how some reportable matters are categorised.

Flying-hour and movement data

Australian flying-hour data and movement data were provided by the Bureau of Transport and Regional Economics, Aviation Statistics section. The flying hours data included both high capacity and low capacity[6] RPT for regional and domestic flights. This excluded cargo only flights and international flights but included the domestic leg of international flights.

The movement data included both high capacity and low capacity RPT movements for both domestic and international flights. Flying hours data for all international flights is not collected. Since the numerator or occurrence data included occurrences that involved foreign registered aircraft, the movement data is the most appropriate denominator for calculating rates.

6 High capacity means the aircraft's certificate of type approval permits a maximum seating capacity of more than 38 seats or a maximum payload of more than 4,200kg (Civil Aviation Order (CAO) 82.0 s. 2). Low capacity refers to aircraft used in RPT operations other than high capacity aircraft.

3 ANALYSIS OF THE DATA AND DISCUSSION

The number of recorded events for each type of immediately reportable matter (IRM), flying hours, and movement data for regular public transport (RPT) flights were sorted into 6-month time periods and graphed. The rates for each of the IRM categories were also calculated and graphed. A rate for each IRM category was calculated to provide a more informative indicator of change over time. Rates were calculated as either occurrences per 100,000 movements (one take-off and landing), or occurrences per 100,000 flying hours.

3.1 Flying hours and aircraft movements

Figure 2 below indicates that there was a generally steady increase in flying hours for each 6-month period over the 5 years studied. The second half of 2005 showed the highest number of flying hours for RPT in Australia with 413,000 hours flown domestically.

Figure 2: Domestic flying hours and domestic and international aircraft movements, 1 July 2001 to 30 June 2006

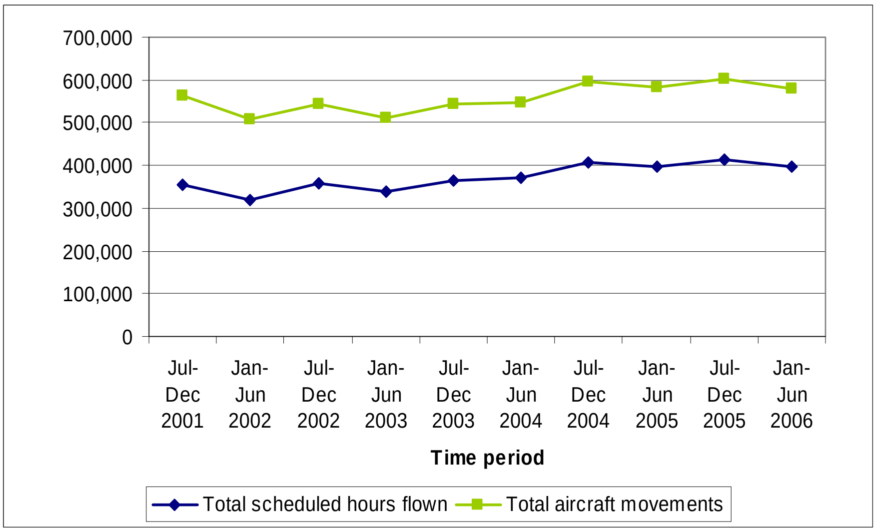
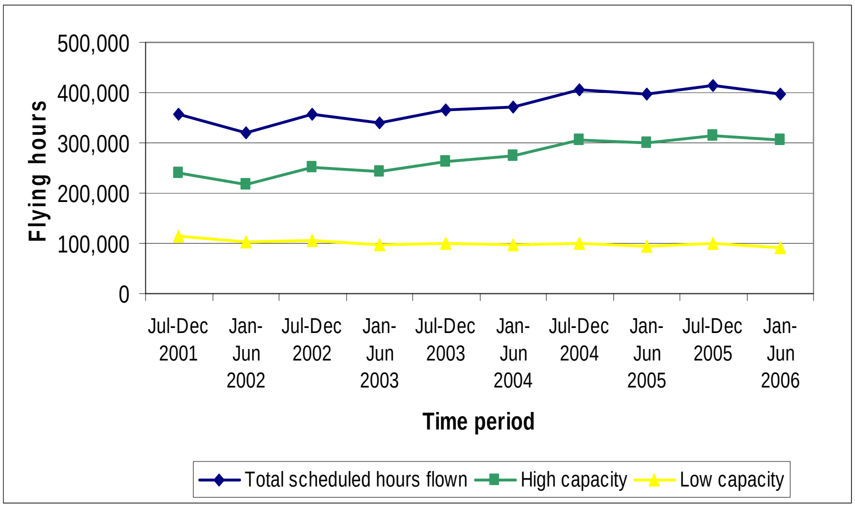


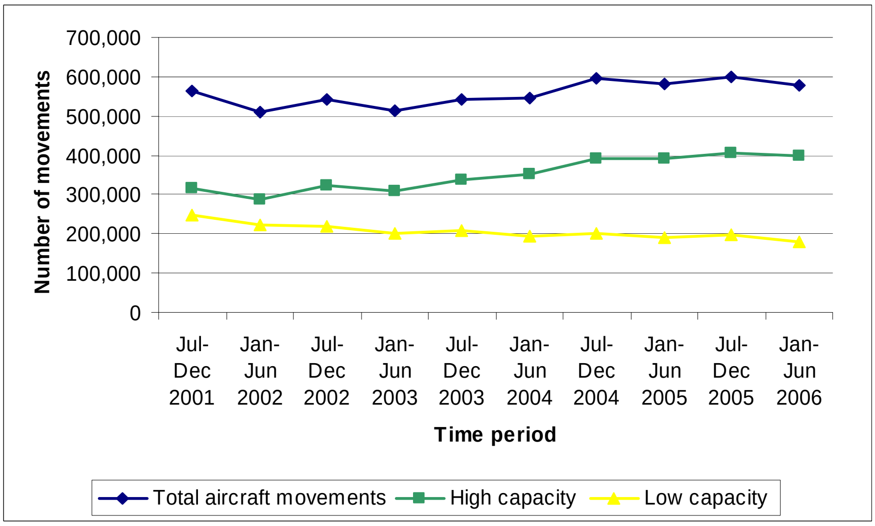
Figure 3 demonstrates that domestic activity is largely determined by the hours flown by high capacity RPT aircraft. Low capacity operations contribute around 27 per cent of the hours flown.

Figure 3: Domestic flying hours by type of air transport operation



There was a 27.5 per cent increase in flying hours for high capacity operations, but a 21.5 per cent decrease in low capacity domestic flying hours over the period studied. The increase in high capacity activity was driven by expansion within existing airlines, the introduction of new airlines and acquisition of high capacity aircraft by regional airlines.

Figure 4: Domestic and international aircraft movements by type of air transport operation

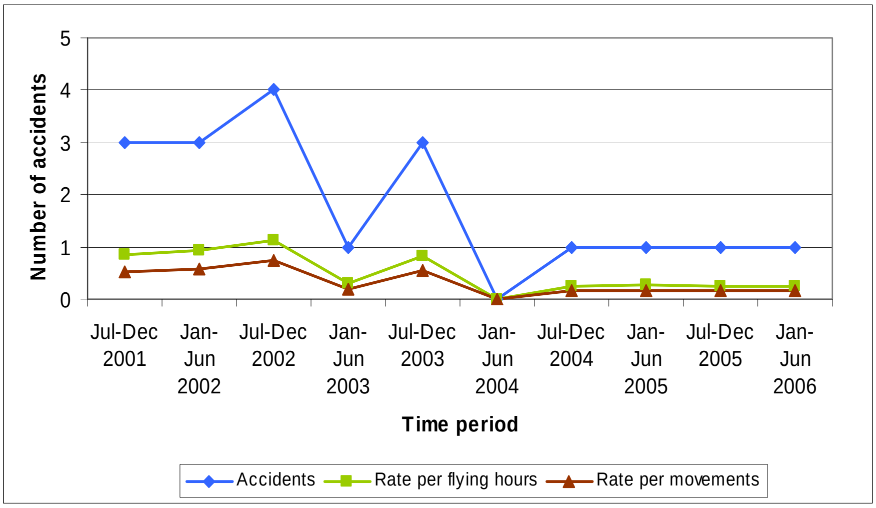


There was a 27 per cent increase in movements from the July-December 2001 period to the January-June 2006 period for high capacity aircraft, matching the change in the number of flying hours. There was a 28 per cent decrease in low capacity aircraft movements for the same period. It is possible that the larger decrease in movements compared with the decrease in flying hours for low capacity RPT aircraft is the result of change in their route structure (more longer segments and fewer shorter ones) and reduced frequency of flights on routes where higher capacity aircraft were introduced (Figure 4).

3.2 Trend data

3.2.1 Reportable accidents

Figure 5: Accidents and accident rate per 100,000 flying hours and 100,000 movements, 1 July 2001 to 30 June 2006



The above graph demonstrates that very few accidents occurred during public transport operations and the numbers have remained low over the 5-year period.[7] The rate of accidents per flying hours and per aircraft movements reflect the same pattern observed in the actual numbers. Only one fatal accident involving an RPT aircraft occurred during the period.

Three examples of accidents that occurred during the period studied are set out below. They include damage to an aircraft, the one fatal accident, and an accident that resulted in serious injury. Each reflects a different element in the definition of an accident.

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7 This section corresponds to immediately reportable matters for all aircraft operations, letters a through to e (see Appendix A).

Occurrence number 200501977

On 7 May 2005, a Fairchild Aircraft Inc. SA227-DC Metro 23 aircraft, with two pilots and 13 passengers, was being operated on an instrument flight rules regular public transport service from Bamaga to Cairns, with an intermediate stop at Lockhart River, Queensland. At 1143:39 Eastern Standard Time, the aircraft impacted terrain in the Iron Range National Park on the north-western slope of South Pap, a heavily timbered ridge, approximately 11 km north-west of the Lockhart River aerodrome. At the time of the accident, the crew was conducting an area navigation global navigation satellite system (RNAV (GNSS)) nonprecision approach to runway 12. The aircraft was destroyed by the impact forces and an intense, fuel-fed, post-impact fire. There were no survivors.

The accident was almost certainly the result of controlled flight into terrain, that is, an airworthy aircraft under the control of the flight crew was flown unintentionally into terrain, probably with no prior awareness by the crew of the aircraft's proximity to terrain.

Occurrence number 200201693

An aircraft was descending through FL350 (35,000 feet) when it encountered a rapid windshear change from 30 kts of tailwind to 15 kts of crosswind component. The autopilot disconnected and the aircraft pitched up. The crew deployed the speed brake fully to prevent a Mach number (Mmo) overspeed. During this manoeuvre a cabin crew member fell and broke her lower right leg.

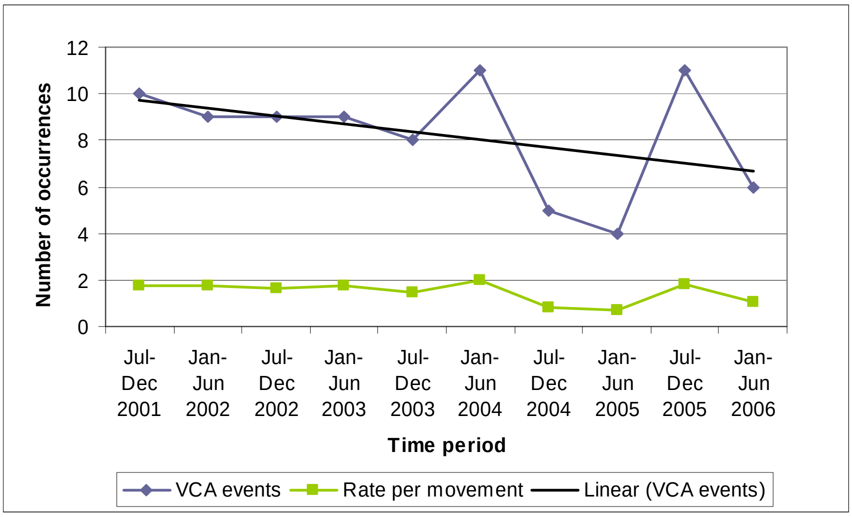
Occurrence number 200404072

A disabled persons' lift was being moved when it collided with a parked Boeing 737-8FE aircraft. The collision caused damage to the winglet and resulted in the aircraft becoming unserviceable.

3.2.2 Violation of controlled airspace

There were 82 violations of controlled airspace by RPT aircraft in the 5-year period studied. Figure 6 presents the number of VCAs for each 6-month period between July 2001 and June 2006. The graph indicates that there was a downward trend in VCA occurrences reported to the ATSB since July 2001. The rate of VCAs per 100,000 aircraft movements also shows a downward trend.

Figure 6: Violation of controlled airspace, 1 July 2001 to 30 June 2006



Note: Two occurrences refer to two aircraft violating the same airspace, at the same location, with the second aircraft entering the airspace directly after the first. These occurred in December 2001 and November 2005. The second aircraft is not counted as a separate occurrence.

A small peak in VCAs was observed for the 6-month period following the introduction of the TSI Act in July 2003. The graph also shows increased variability in VCA reports since the July-December 2003 period, which also coincides with the introduction of new airspace architecture, NAS stage 2b, in November 2003. To better understand the nature of the apparent volatility of VCA notifications in the period between January 2004 and June 2006, and to examine whether the TSI Act or NAS stage 2b changes may have influenced the number of VCA notifications monthly data was examined (Figure 7).

Figure 7: Violation of controlled airspace by month, January 2003 to end June 2006

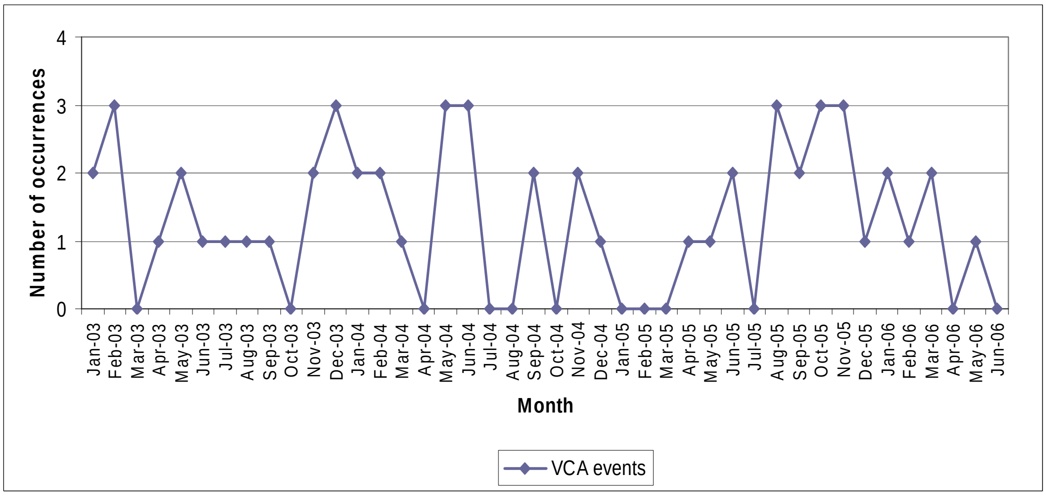
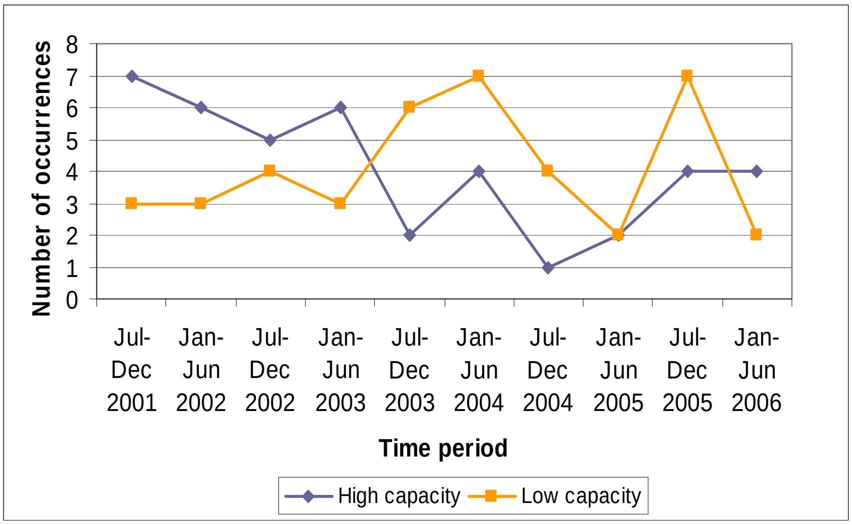


Figure 7 shows that the apparent variability shown in the later period of Figure 6 is an artefact of combining data into 6-month blocks, and as a consequence of normal variation between months where the number of VCA events is relatively low. Figure 7 also indicates that there was a greater change in the number of VCA events following the introduction of NAS stage 2b at the end of November 2003 compared with the period immediately following the introduction of the TSI Act in July 2003.

High capacity and low capacity operations

The downward trend in VCA events is clearer for high capacity RPT operations (Figure 8).

Figure 8: Violation of controlled airspace by air transport type, July 2001 to June 2006

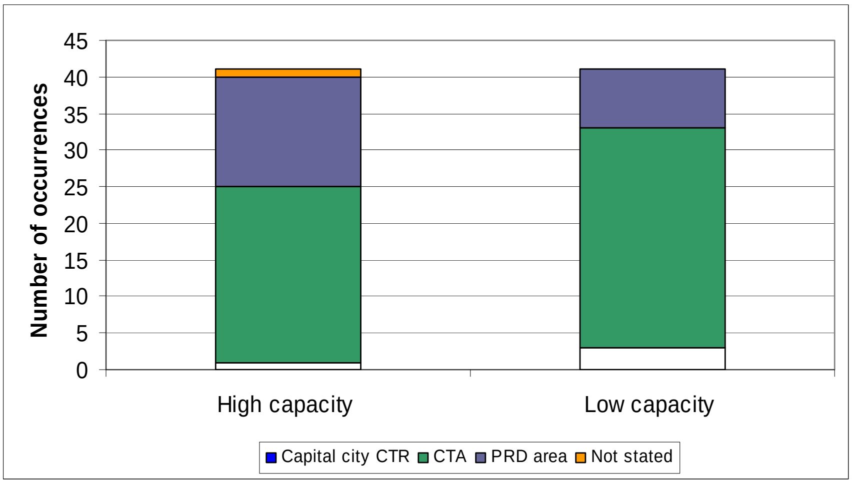


The 82 VCA occurrences occurred in equal number for high capacity and low capacity aircraft operations. Violation of controlled airspace involving low capacity aircraft ranged from two to seven for each 6-month period, while the number that involved a high capacity aircraft ranged from one to seven each period. There was considerable variability in the number of VCA events between periods, but VCA events for high capacity aircraft operations appeared to generally decline over the period studied, while no particular trend for low capacity aircraft operations could be observed.

Airspace

The data for VCA events was also analysed by the type of airspace involved for each occurrence. Figure 9 shows which type of airspace was most commonly involved in VCA occurrences for low and high capacity RPT operations. Entry without a clearance into controlled airspace, other than the control zone around an airport, was the most frequent event. The next most common reason for a VCA was entry into restricted airspace without a clearance, although this is less frequently the case for low capacity RPT compared with high capacity RPT operations.

Figure 9: Type of airspace violated by air transport operation type, July 2001 to June 2006



Note: CTR refers to a control zone and is defined as the controlled airspace around an aerodrome

CTA is an abbreviation for controlled airspace and refers to controlled airspace that is not a control zone (CTR) (Aviation Theory Centre, 2004; National Airspace System Implementation Group, 2003).

PRD areas include prohibited, restricted and danger areas.

Contributory factors

Table 1 outlines the primary contributing factor in the VCA event. In 90.2 per cent of occurrences, actions by the crew led to the VCA. The most common crew error was the failure to request a clearance, while the next most common reason was a failure to comply with ATC instructions.

Table 1: Contributory factor in occurrences involving violations of controlled airspace

Contributory factor		High capacity	%	Low capacity	%	Total
ATC related		6	14.6	2	4.9	8
Crew	Diversion due to weather	8	19.5	0	0	8
	Failure to comply with an ATC instruction	9	22	8	19.5	17
	Flight management computer error	2	4.9	0	0	2
	Incorrect chart	0	0	1	2.4	1
	No clearance requested	11	26.8	29	70.7	40
	Track deviation	5	12.2	1	2.4	6
Total		41		41		82

It was difficult to identify all the underlying factors in occurrences involving a failure to request a clearance or a failure to comply with an ATC instruction due to insufficient information in the notification report. Factors such as distraction or workload, area familiarisation, and use of incorrect charts are a few examples of potential underlying factors but without additional evidence they could not be reliably identified. Violations of controlled airspace associated with ATC activities included: improper use of the NOTAM system; incorrect NOTAMs; breakdown of coordination and issuing incorrect headings.

High capacity operations differed from low capacity operations with more diversions due to weather and track deviations, but fewer VCAs as a result of failing to obtain a clearance.

The downward trend in VCA events is encouraging, especially as high capacity RPT activity has increased substantially over the period studied. This reduction was driven by fewer ATC-related VCAs, a reduction in failure to comply with ATC instructions and fewer events resulting from diversions due to weather. Despite the overall reduction, the number of VCAs resulting from a failure to request a clearance increased slightly over the 5 years.

Some examples of circumstances that result in a VCA are below.

Occurrence number 200105117

The aircraft was cleared to descend from FL290 to FL270 without prior co-ordination to Sydney ATC departure controllers. The aircraft also entered R595 without prior co-ordination. At this stage ATS advised RAAF Williamtown ATC authorities of the breakdown of co-ordination.

Occurrence number 200600243

While en route, the aircraft was observed on radar to deviate from the cleared route and the pilot was issued heading instructions to track clear of R225. The pilot delayed turning onto the heading and the aircraft entered R225 without a clearance.

Occurrence number 200400228

The aircraft was cleared for the departure climb and instructed to call approaching FL180 for further climb instructions. However, the crew called passing FL190 having entered class E airspace without a clearance. ATC issued further climb instructions and there was no infringement of separation standards. ATS advised that the CTA lower limit in the area had changed to FL180 from FL200, with the introduction of NAS and class E airspace arrangements in November 2003.

Occurrence number 200506209

Air traffic control received a NOTAM advising of a retrospective activation of R240 and R250A. At the time the NOTAM was issued, one aircraft was within the restricted area and one was about to enter.

Occurrence number 200303715

The controller incorrectly issued the crew with an incorrect heading of 040deg instead of 140deg. On realising the error, the controller issued corrective headings. In the subsequent manoeuvres the aircraft was observed on radar to penetrate R350.

3.2.3 Breakdown of separation and airprox

Breakdown of separation (BOS) events and airproxes can occur between two or more aircraft, a parachutist and an aircraft or an aircraft and a vehicle on the runway. The following results refer to a combination of all three event types.

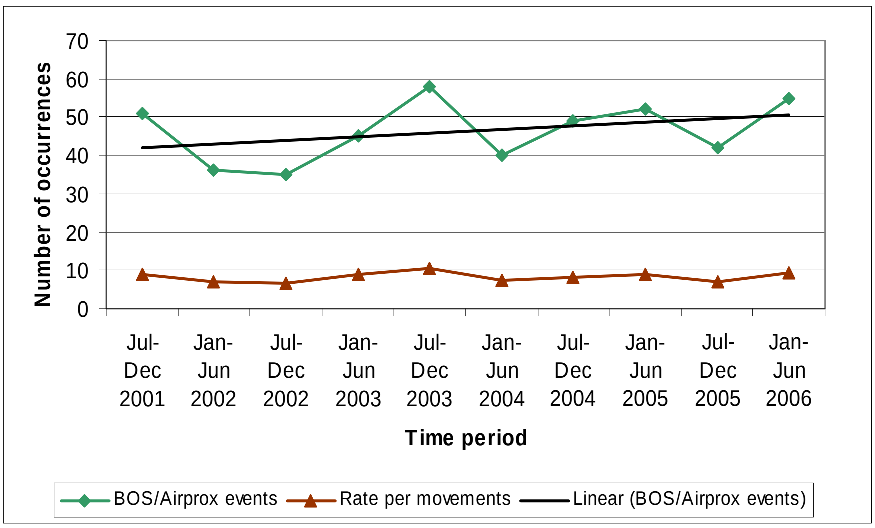
The number of BOS and airprox events fluctuated over the period reviewed but remained within the range of 35 to 58 events each time period (Table 2). Of these 463 occurrences only two per cent (10 occurrences) were sufficiently serious to warrant investigation by the ATSB.

Table 2: Breakdown of separation and airprox event, July 2001 to June 2006

Time period	Frequency
July-December 2001	51
January-June 2002	36
July-December 2002	35
January-June 2003	45
July-December 2003	58
January-June 2004	40
July-December 2004	49
January-June 2005	52
July-December 2005	42
January-June 2006	55
Total	463

Rate of BOS and airprox events

Figure 10: Breakdown of separation and airprox events and rate per 100,000 movements, 1 July 2001 to 30 June 2006



The rate of BOS and airprox events did not exceed 10.6 per 100,000 movements in any 6-month period, and averaged 8.3 per 100,000 movements over the 5 years studied.

Combining the BOS and airprox data in Figure 10 allows for a trend analysis of BOS and airprox events even though the NAS stage 2b airspace classification changes potentially affected the categorisation of some occurrences. For example, the change from Class C to Class E airspace, where there is no separation service between IFR aircraft and VFR aircraft, meant that occurrences that previously would have been classified as BOS events between an IFR and a VFR aircraft became classified as airprox events.

Two peaks in the rate were observed, one in the July-December 2003 period and another in the January-June 2005 period. Interestingly, the peak in reported BOS/airproxes in the July-December 2003 period coincided with the introduction of the TSI Act at the beginning of July 2003 and introduction of NAS Stage 2b in November 2003. During this period there were eight or nine BOS or airprox events each month until December when the number increased to 15. This suggests that the peak in 2003 may have been partly a consequence of NAS airspace changes rather than the introduction of the TSI Act.

Seventy nine and a half per cent of the events (368 occurrences) were BOS while 20.5 per cent (95 occurrences) were airprox events.

Figure 11: Breakdown of separation and airprox events and rates per 100,000 movements, 1 July 2001 to 30 June 2006

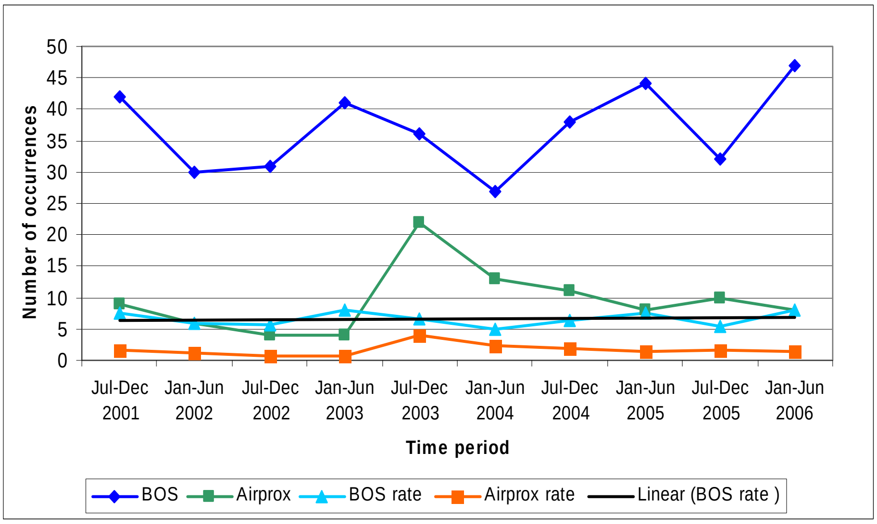


Figure 11 displays the trend in BOS and airprox events separately along with the associated rate per aircraft movement. The number of BOS increased over the period as did airprox events, albeit to a smaller degree. While the actual number of BOS and airproxes increased, the respective rates between the end of 2001 and mid 2006 did not.[8] However, the previously mentioned peaks in airproxes in the July to December 2003 period and in BOS in the January to June 2005 period were significantly higher than the periods that immediately preceded them.

Given the finding that the rate of BOS events did not significantly increase, the correlation between flying activity and number of BOS was calculated. This was calculated on BOS that involved high capacity aircraft and high capacity aircraft

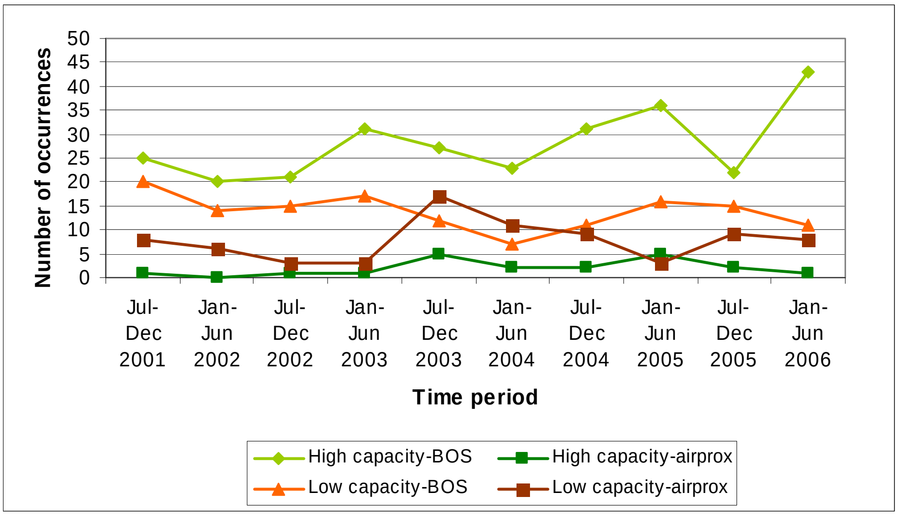
8 Poisson regression was used. For the rate of BOS: χ^2=0.16, p=0.69. For the rate of airprox events: χ^2=0.09, p=0.76.

movements. The results indicated a positive and moderately strong correlation between the number of BOS and aircraft movements[9], suggesting that increased activity helps explain the increase in BOS.

High capacity and low capacity operations

The trend in BOS/airprox events differed between high capacity operations and low capacity operations. There was an observable increase in the number of BOS events over the period for high capacity operations, but a decrease in events involving low capacity aircraft. Airproxes involving high capacity aircraft were uncommon and remained unchanged over the time period, while airproxes involving low capacity aircraft increased slightly (Figure 12). Like the overall rate of BOS, the rate for high capacity BOS did not increase between the end of 2001 and mid 2006.[10]

Figure 12: Breakdown of separation and airprox events by type of air transport operation, 1 July 2001 to 30 June 2006[11]



Aircraft involved

The greatest proportion of BOS events that involved a high capacity air transport aircraft were with another RPT aircraft (50 per cent). Another 17 per cent was between a high capacity aircraft and general aviation aircraft (flying training, charter or other aerial work), while five per cent involved a high capacity aircraft and a military aircraft. Unfortunately 21 per cent of occurrences where a high capacity aircraft was involved was with an aircraft were the operation type was not known. In addition, there were seven BOS events between a vehicle on the runway and a high capacity aircraft and three BOS involving a parachutist and a high capacity aircraft. None of the occurrences involving a parachutist was serious enough to require investigation beyond initial notification of the occurrence.

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9 Pearson r=.35, p=0.01.

10 Poisson regression was used. χ^2=1.45, p=0.23.

11 These figures will not sum to the total number of BOS and airprox events because one event could involve a high capacity and a low capacity aircraft.

Forty six per cent of low capacity BOS events involved two RPT aircraft while 20 per cent were between an RPT aircraft and an aircraft performing general aviation activities. Again the type of flying operation for a large proportion of aircraft involved in low capacity BOS could not be identified (26 per cent). One BOS involved a low capacity aircraft and a vehicle on the runway.

Airspace and location

Twenty nine per cent of high capacity BOS occurred in capital city CTR and 60 per cent occurred in other CTA. Breakdowns of separation that involved a low capacity aircraft occurred in capital city CTR (27.5 per cent), CTR (12.3 per cent) and other CTA (58 per cent).

The largest percentage of airprox events occurred in mandatory broadcast zones (MBZ) or common traffic advisory frequency (R) (CTAF(R)).[12] Over 55 per cent of the high capacity airprox events occurred in a MBZ/CTAF(R) while 60 per cent of low capacity airprox events occurred in a MBZ/CTAF(R). The observed peak in July-December 2003 was due to a jump in the number of airproxes within MBZ/ CTAF(R). This jump in airprox events occurred before any changes in the operating procedures at MBZ was introduced with NAS Stage 2c on 24 November 2005. The increase was not sustained in the subsequent 6-month period.

The number of high capacity BOS that occurred in capital city CTR or CTA increased over the 5-year period.

While the location of the BOS or airprox was spread around the country there was a concentration of events at the two busiest aerodromes, Sydney and Melbourne. Around 10 per cent of events occurred at these airports, with even more in the approaches to both of these aerodromes.

Contributory factors and recovery measures

Table 3 presents the contributory factors for all BOS and airprox events by type of RPT operation. In the high capacity BOS events, 54.5 per cent of occurrences were attributable to ATC procedures and 43.7 were attributable to crew actions or procedures. Another one per cent was attributed to a vehicle driver and the remainder were unknown. Of the crew related occurrences, half of the occurrences were attributable to the crew actions or procedures of the high capacity RPT aircraft as opposed to the non-RPT aircraft crew.

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12 Mandatory broadcast zones or MBZ were replaced by common traffic advisory frequency (R) (CTAF (R)) with the introduction of National Airspace System Stage 2c on 24 November 2005. The CTAF is a radio frequency on which pilots make positional broadcasts when operating in the vicinity of a non-towered aerodrome. A CTAF (R) indicates that only aircraft fitted with a working radio are permitted to operate at that aerodrome (Department of Transport and Regional Services, 2005).

Table 3: Contributing factor to breakdown of separation events

Contributing factor		High capacity	Low capacity
ATC procedures		152	66
Crew	Communication procedures	1	3
	Failure to comply-altitude bust	34	25
	Failure to comply-instruction/heading change/track deviation/procedures	45	17
	Failure to comply-handling/overshot final approach	7	1
	Violation of controlled airspace	32	23
	Self-separation procedures	1	1
	Other	1	1
Vehicle-runway incursion		3	1
Other/unknown		3	0
Total		279	138

In the low capacity BOS events, 47.8 per cent of occurrences were the result of ATC procedures and 51.4 per cent were the result of crew actions or procedures. Of the crew related occurrences, 42.3 per cent were attributable to the crew of the RPT aircraft as opposed to the crew of the non-RPT aircraft.

Air traffic control procedures that contributed to BOS events included: instructions or clearances that did not maintain separation assurance such as incorrect headings or clearance to a conflicting flight level; use of an inappropriate separation standard; judgement and calculation errors when determining closure or climb rates, times of passing or sequencing of landings; unclear or non-standard communication of instructions to flight crew; and not passing required traffic information. Some of the underlying factors in these events, that could be identified from the notification report, included controller fatigue; distraction; channelled attention; insufficient knowledge; or inadequate judgement.

The final responsibility for maintaining separation between aircraft always falls to the pilot in command, irrespective of the services provided by ATC.

The most common detection and recovery measures were ATC noticing and correcting the problem, aircrew detecting and responding to the conflict and traffic collision avoidance system (TCAS)[13] alerts or the activation of other onboard warning devices. In 67 per cent of occurrences ATC corrected the conflict while aircrew detected and implemented appropriate action in 28 per cent of occurrences.

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13 The on-board TCAS system communicates with other proximal aircraft to determine their bearing, altitude and range. This information is then used to calculate the future position of that aircraft and the potential for a collision. Flight crews are either alerted to the presence of another aircraft by the TCAS system or if a collision threat is identified, the system will determine the appropriate avoidance manoeuvre for both aircraft and advise each crew accordingly.

The remaining 4.5 per cent of occurrences were addressed by either a combination of ATC and crew or in three instances by a third party.

The methods used by crews to detect the conflict were visually sighting the other aircraft and a TCAS alert. Some of the methods used by ATC to detect BOS events included an electronic alert from The Advanced Australian Air Traffic System (TAAATS), visual detection on a radar screen or visual sighting of the aircraft from the tower.

Summary

The number of BOS events increased. The increase was driven by an increase in occurrences that involved high capacity aircraft, especially in capital city CTR and other CTA airspace. The number of airproxes increased slightly over the period and occurred primarily in MBZ/CTAF(R). Despite the jump in numbers, the rate per aircraft movement did not significantly increase.

A previous study of BOS, airprox and VCAs, that aimed to gauge the impact of NAS stage 2b, was conducted six months after the NAS stage 2b changes commenced (Australian Transport Safety Bureau, 2004). The BOS and airprox results for RPT operations in the two studies were broadly similar in that the rate of BOS and airprox did not significantly change between the 6-month period before the introduction of NAS stage 2b and the 6-month period that followed. This current study considers a longer time period and demonstrates that any increase in the number of airspace-related occurrences was short lived. The number of events returned to historical levels with no obvious longer term change attributable to either NAS stage 2b or the TSI Regulations.

Australia’s airspace has become busier over the period studied and remains a complex and sophisticated environment to manage. The most common contributing factor identified in BOS events was ATC procedures. Similarly, the ATC system, which includes both controllers and their supporting technology, was also most often responsible for preventing an escalation of BOS events.

Overall, the results indicate that while the number of BOS events increased, the rate of BOS/airprox events and the rate for high capacity aircraft alone, measured as events per 100,000 movements, did not. The correlation between high capacity aircraft movements and the number of high capacity BOS was statistically significant, supporting the argument that the increase in the number of BOS was activity driven.

Some examples of BOS events are included below.

Occurrence number 200201741

The pilot of an aircraft contacted ATC inbound to Tamworth and requested an airways clearance when the aircraft was already in CTA. This resulted in an infringement of separation standards between the aircraft and a de Havilland Dash 8 aircraft inbound from Armidale. A traffic alert was issued as the vertical separation between the two aircraft reduced to 800 ft. Vertical separation of 1,000 ft was then re-established and the pilot of the aircraft that had violated CTA was issued with an airways clearance.

Occurrence number 200505170

On 20 October 2005, a Boeing Company 777-2B5ER aircraft (777), was taking off from runway 34 left (34L) at Sydney (Kingsford Smith) Airport on a scheduled passenger flight to Seoul, South Korea. After the 777 commenced the take-off run, an aircraft tug, with a Boeing Company 747-400 freighter aircraft (747) in tow crossed the departure end of the same runway. There was a runway incursion.

The investigation found that the tug driver involved in the occurrence had 17 years experience in driving a tug at Sydney Airport. In that time he had not been involved in any other recorded incident. Despite his extensive experience and the ongoing training and checking regime that were in place at Sydney Airport, the driver of tug thought that a clearance issued to the pilot of a taxiing aircraft was for the tug driver.

The driver believed he heard a clearance to cross runway 34 left from the surface movement controller east (SMC E). The driver acknowledged that clearance in accordance with published procedures but the SMC E remained unaware of the situation due to a radio overtransmission. In the absence of any response from the SMC E the driver continued to cross the runway. From that point on, there was limited time available to prevent the runway incursion.

Occurrence number 200305235

At 30 NM and tracking 189 degrees magnetic inbound on the Launceston (LT) VOR, ATC cleared the crew of the Boeing 737 (737) for a visual approach. Approximately four minutes later the crew of the 737 reported that they had responded to a TCAS resolution advisory on traffic at 11 NM LT at 7500 ft. Shortly afterwards, the pilot of a Socata TB-10 (Tobago) contacted LT Tower and advised that he believed his aircraft was the traffic the crew of the 737 had reported. He also stated that he believed under the new procedures that he should remain silent to avoid unnecessary chatter.

After landing the pilot of 737 reported that the TCAS indicated that the Tobago passed slightly left of and 200 ft below the 737.

Occurrence number 200103055

ATC reported that both aircraft were tracking inbound to Perth from the east via the BADJA waypoint at FL350. As VH-TJR was the leading aircraft, the controller reduced the airspeed of VH-OGU and applied radar vectoring to increase the spacing between them for landing. However, the initial heading change issued to OGU did not take the ambient wind velocity into account and its groundspeed increased by 50 knots. The controller then realised that there was a likelihood that radar separation would reduce to the minimum permissible and he issued immediate descent instructions to TJR and further radar headings to OGU. Despite this the aircraft came to within 4.8 NM of each other while vertical separation standards did not exist between them. Traffic information was issued and both crews sighted the other aircraft but there was an infringement of separation standards.

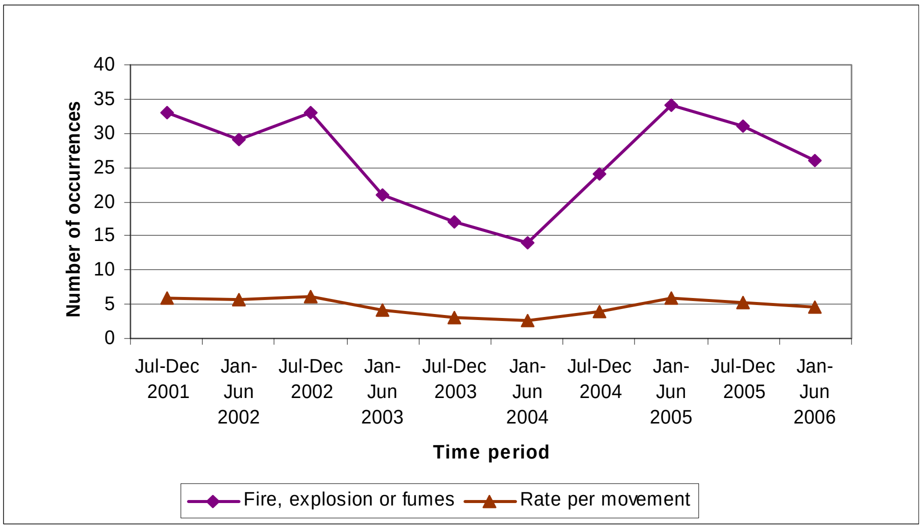
3.2.4 Fire, smoke, explosion or fumes

Table 4 and Figure 13 show that there were between 14 and 34 reported occurrences of either fire, smoke, or fumes for each 6-month period. The number of occurrences trended downwards, before increasing in the second half of 2004. While the TSI Regulations refer to this category of IRM as 'fire, smoke, fumes or explosions', there were no explosions reported in this time period.

Table 4: Reported fire, smoke, explosions or fumes, 1 July 2001 to 30 June 2006

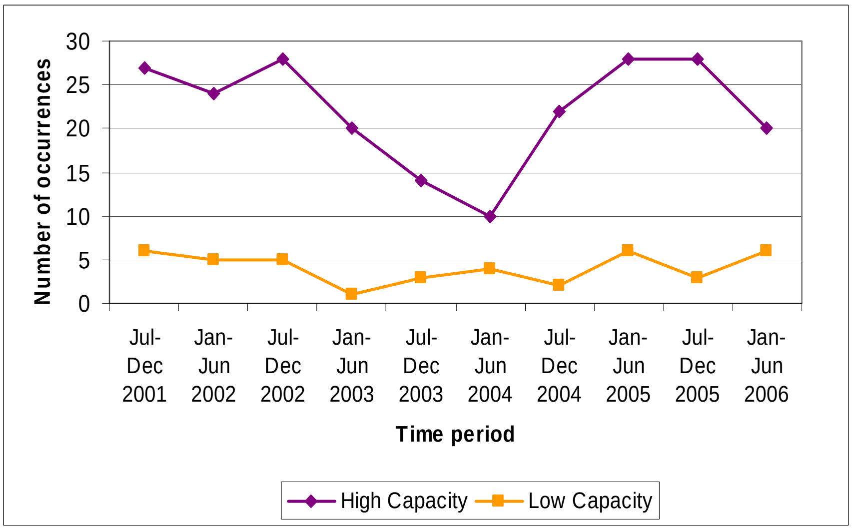
Time period	High Capacity	Low Capacity	Total
July-December 2001	27	6	33
January-June 2002	24	5	29
July-December 2002	28	5	33
January-June 2003	20	1	21
July-December 2003	14	3	17
January-June 2004	10	4	14
July-December 2004	22	2	24
January-June 2005	28	6	34
July-December 2005	28	3	31
January-June 2006	20	6	26
Total	221	41	262

Figure 13: Reported fire, smoke, explosions or fumes occurrences and rate per 100,000 aircraft movements, 1 July 2001 to 30 June 2006



Most of the occurrences were reported during high capacity operations (Figure 14), though this is unsurprising given that activity for high capacity aircraft is around three times that of low capacity aircraft.

Figure 14: Reported fire, smoke, explosions or fumes occurrences by type of air transport operation, 1 July 2001 to 30 June 2006



Twenty occurrences (7.6 per cent) involved a fire, 140 occurrences (53.4 per cent) involved fumes[14], 98 occurrences (37.4 per cent) involved smoke[15] and four occurrences were due to cigarette smoke. Fires were located in the brakes, landing gear, engines, galley ovens, cockpit (due to overheating of electrical components), or in the toilet where passengers had been smoking. Occurrences involving smoke were due to overheating of electrical components, overheating of the brakes, oil residues or leaks, component failures or burning food in the galley. Fumes resulted from a vast number of sources, some of which were unable to be identified by aircraft engineers. Sources of fumes included oil or solvent residues following maintenance activities, failed or overheated electrical or mechanical components, or passenger's luggage.

By far the most common type of event was fumes detected in the cabin of the aircraft, often following aircraft maintenance. Smoke or fumes from burning food in the galley was also common.

In the past, the problem of fumes in the cabin has received publicity. Table 5 indicates that in Australia the Boeing 737 and 767 models were involved in more reports of fumes than any other model. This data needs to be placed in context, presented with information on the number of each type of aircraft in service. At the time of publication there were more Boeing 737 aircraft on the Australian register than any other type of high capacity aircraft. In September 2007 there were 40 per cent more VH-registered Boeing 737 aircraft than the combined number of B747, B767 and BAe 146 aircraft.

14 Fumes included odours, burning smells, vapour or detection of mist with odours.

15 The smoke category included the presence of smoke without flames.

Table 5: Aircraft make and model with reported fumes

Aircraft make and model	Occurrences involving fumes	Percent
Boeing Co 737	40	28.6
Boeing Co 767	37	26.4
Boeing Co 747	6	4.3
British Aerospace Plc BAe 146	24	17.1
De Havilland Canada DHC-8	13	9.3
Fairchild Industries Inc SA227	7	5.0
Airbus Industrie A330	3	2.1
Other aircraft	10	7.1
Total	140	100.0

The phase of flight when the fumes, fire or smoke was detected was analysed. Table 6 demonstrates that fires primarily occurred when the aircraft was on the ground or landing. Fumes occurred predominantly when the aircraft was in the air and smoke events were split between on the ground and in the air for high capacity aircraft, but primarily detected while the aircraft was en route in low capacity aircraft.

Table 6: Phase of flight for reported fire, smoke, explosions or fumes

Operation type	Phase of flight	Fumes	Smoke	Fire	Cigarette smoke	Total
High capacity	Aircraft standing	10	13	9	0	32
	Approach	13	3	1	0	17
	En route	74	25	2	3	104
	Landing	1	19	2	0	22
	Manoeuvring	1	0	0	0	1
	Take-off	13	3	1	0	17
	Taxiing	12	15	1	0	28
Low capacity	Aircraft standing	2	1	0	1	4
	Approach	3	1	0	0	4
	En route	7	13	1	0	21
	Take-off	2	2	1	0	5
	Taxiing	2	3	2	0	7
Total		140	98	20	4	262

The vast majority of occurrences resulted in nil (97 per cent) or minor (2 per cent) injuries. Only one occurrence resulted in serious injury, which occurred during an evacuation procedure following a brake fire. This occurrence is described further in section 3.2.6.

The threat of fire, fumes or smoke is among the most serious occurrences. In response to the signs of fire, fumes or smoke, crews need to take the necessary steps to ensure the flight concludes safely. This might include a decision to divert the aircraft to the nearest suitable aerodrome, where the source of the threat can be investigated safely.

Several examples from this category of IRM are presented below.

Occurrence number 200506676

During cruise, the crew noticed a strong gas smell in the cabin. The crew declared a PAN and returned the aircraft to Brisbane. A number of passengers were treated with oxygen during the descent. The aircraft landed without further incident and there were no reported injuries. An investigation revealed that a passenger had a leaking gas cylinder in his checked in baggage.

Occurrence number 200103238

During the takeoff roll, the cabin manager became aware of a smoky, burning smell coming from an air vent in the region of her crew seat. Initially there was a mild odour. That was followed by the rapid onset of strong fumes for a short period after which the fumes dissipated quickly. The event was of 2-3 minutes duration.

The cabin manager felt overwhelmed by the fumes and was on the verge of passing out when her colleagues became aware of the situation and provided her with portable oxygen.

The cabin manager sought medical treatment and tests on the day of the incident. Blood tests revealed she had been exposed to a higher than normal level of carbon monoxide. Carbon monoxide is the product of incomplete combustion of carbonaceous material. It is found in varying amounts in the smoke and fumes from burning aircraft engine fuels and lubricants.

Evidence from previous incidents of air system contamination indicated that fumes were associated with engine or auxiliary power unit oil contamination of the air-conditioning system.

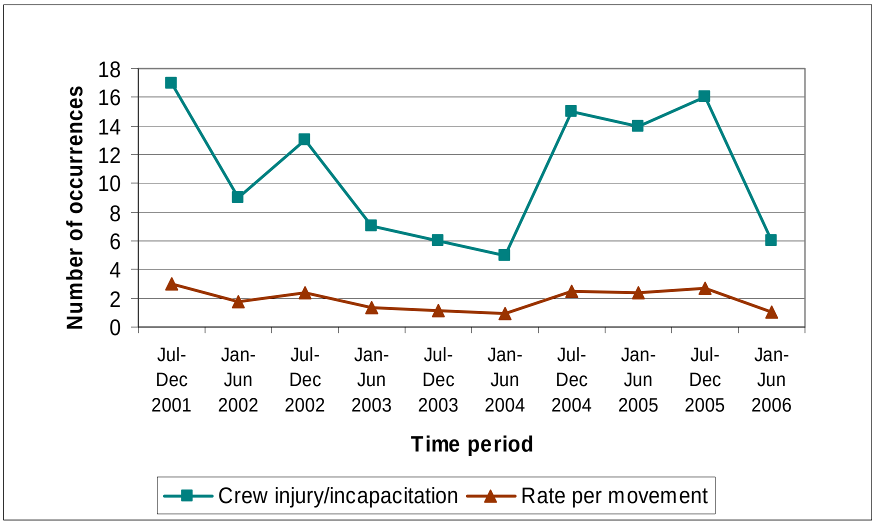
Occurrence number 200103457

The crew of a Metro 23 noticed smoke coming from beneath the instrument glare shield as they taxied to the holding point. After all essential and non-essential buses were disconnected the smoke ceased. The operator's engineers subsequently found that a chafed wire had resulted in electrical arcing and smoke.

3.2.5 Crew injury or incapacitation

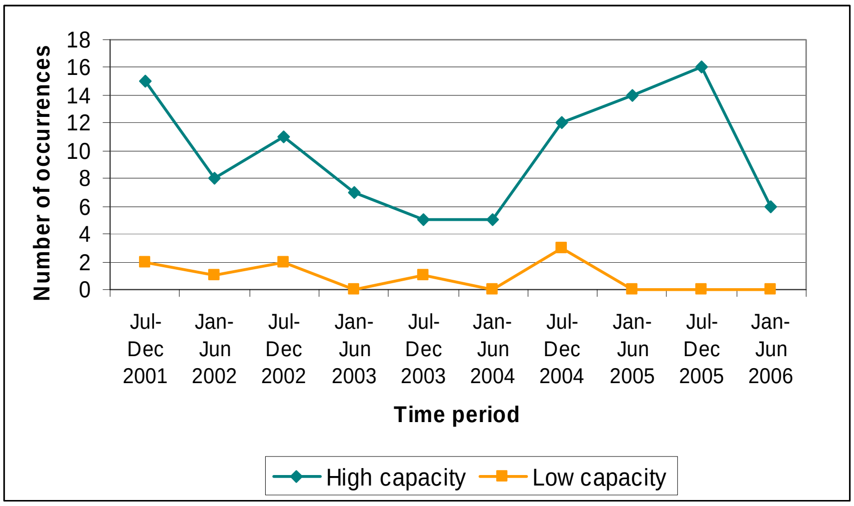
Figure 15 indicates that the overall number of crew incapacitation or injuries was low and variable. The rate of crew injury or incapacitation trended downward.

Figure 15: Crew injury or incapacitation and rate per 100,000 aircraft movements, 1 July 2001 to 30 June 2006



Given the relative flying hours of high capacity and low capacity operations, it is not surprising that more crew injuries and incapacitation were observed in high capacity operations (Figure 16). Also, the number of cabin crew required on passenger transport operations is determined, in part, by the number of passengers carried. It is based on a ratio of one attendant per 36 passengers (see Civil Aviation Order (CAO) 20.16.3). Hence, high capacity aircraft require many more cabin crew than low capacity aircraft.

Figure 16: Crew injury or incapacitation by type of air transport operation



Seventy four per cent of these occurrences involved cabin crew while 24 per cent involved a member of the flight crew. The most common cause of cabin crew injury was turbulence or a sudden aircraft manoeuvre when the crew member was unrestrained (66 per cent). The most common scenario involving the flight crew was illness (69 per cent). The level of injury was generally minor. Only two occurrences resulted in serious injury of crew. In the first occurrence, a cabin crew member fell and broke her leg as the pilot deployed the speed brake in response to windshear, and in the second occurrence, a flight crew member and three passengers were injured during an evacuation caused by a landing gear fire.

Like the fire, smoke or fumes events, occurrences associated with crew injury/incapacitation decreased. Serious crew injury or illness was rare. These results support the findings from a previous analysis of incapacitation events by the ATSB (Newman, 2007). Newman (2007) studied pilot incapacitation between 1975 and 2006 and reported a downward trend over a much larger period than the 5 years reviewed in the current study. In that study, the most common cause of pilot incapacitation was acute gastrointestinal illness due to food poisoning and exposure to toxic smoke or fumes on board the aircraft. The report concluded that these events were largely unforseen events and not associated with pre-existing medical conditions. Moreover, the multi-crew environment meant that the risk to the continued safe operation of the aircraft from this type of event is very low.

Cabin crew are vulnerable to turbulence, which can be difficult to predict. This is especially true for the severe forms of clear air turbulence encountered at higher altitudes, when cabin crew are normally performing duties that require them to move around the cabin.

Below are two examples of occurrences where crew were ill or injured.

Occurrence number 200203222

On climbing through FL110, the co-pilot suffered severe abdominal pain and the crew initiated a return to Sydney. During the descent, the co-pilot's condition deteriorated rapidly and he became completely incapacitated. An ambulance met the aircraft on arrival and the co-pilot was taken to hospital. Further investigation revealed that the co-pilot had suffered a temporary abdominal ailment.

Occurrence number 200302980

On 2 July 2003 a Boeing 747-438 aircraft, operating on a scheduled flight, arrived at Sydney during the airport's curfew period under a tailwind of around 12 knots. The pilot flying selected auto brake setting three and idle reverse thrust in accordance with the curfew requirement. However, during the landing roll, the reverse thrust was inadvertently de-selected.

On arrival at the terminal, the pilot in command observed a BRAKE TEMP advisory message and notified the ground engineers. At that point, a fire ignited on a right wing landing gear brake unit. The flight crew were advised and the pilot in command ordered an evacuation of the aircraft. During the evacuation the upper deck left door and doors 2 left and 4 right escape slides did not deploy. As a result of the evacuation, one flight crew member and three passengers were seriously injured.

During the accident, an additional two brake fires ignited on the right body landing gear, one of which was extinguished by the Aviation Rescue Fire Fighting service. Subsequent inspections found the aircraft's landing gear contained an excessive amount of grease with the presence of inappropriate grease on all landing gear axles. The inappropriate grease was general purpose grease used on other components of the landing gear.

3.2.6 Other immediately reportable matters

Several other types of IRM are prescribed in the TSI Regulations, but examples of these are either rare or entirely absent. For example, no uncontained engine failures were notified to the ATSB for the 5-year period studied.

There was one incidence of fuel exhaustion involving a low capacity regular public airline in September 2005. The aircraft had already diverted to a nearby airport when one engine shut down due to fuel exhaustion in the left fuel tank. The flight crew conducted a single-engine landing at the airport shortly afterwards.

4 CONCLUSIONS

Over the 5 years studied in this report, flying activity in regular public transport (RPT) operations has grown strongly. That increase was driven by a 27 per cent increase in high capacity transport flights, which accounts for about two-thirds of all RPT operations in Australia. The growth is despite the early setbacks caused by the collapse of Ansett Australia and external threats to the industry like SARS and the terrorist attacks on 11 September 2001. By contrast, low capacity RPT activity has declined, but this decrease may be partly the result of the acquisition of larger, high capacity aircraft by regional airlines that have traditionally relied on low capacity aircraft.

The trends in data examined involving immediately reportable matters (IRMs), or the equivalent accident and incident types reported to the ATSB prior to the introduction of the Transport Safety Investigation Act, are encouraging. *Despite the increased activity in scheduled public transport operations, the number of IRM occurrences has generally either remained stable or declined. When measured in relation to airline activity, the trend rate is generally downwards.*

The number of breakdown of separation (BOS) or airprox events appears to go against this trend. However, a closer look at these data reveals two things. Firstly, the increase in BOS incidents appears to be largely linked to the increase in RPT activity. When measured in terms of rate, BOS and airprox events were relatively stable over time. Secondly, most breakdown of separation events were detected early, and defences were used that avoided these developing into more serious threats to aviation safety.

There was no evidence to suggest a significant change in the reporting culture related to IRM occurrences. The ATSB believes that this was partly attributable to an existing effective reporting culture in Airservices Australia (the source of most notifications to the ATSB) and the major airlines, which recognise that safety needs to be at the core of their business. While this report found some volatility in the number of some types of events recorded for each 6-month period examined (for example, violations of controlled airspace, or VCA, since mid 2003), these appear to be an artefact of combining the monthly data into 6-month blocks. Some variation seen in the data might also have been the result of the implementation of significant changes to airspace under the National Airspace System (NAS), which was introduced in stages during the period studied. If NAS changes did influence the number of reports for some IRM events, its effect was short-lived.

The study of IRM trends in Australian RPT operations did not identify any serious or sustained reduction in aviation safety. The ATSB will continue to monitor these trends, and publish results periodically to better inform industry and the broader public. Following this study, the ATSB plans to conduct an analysis of IRM occurrences for charter operations and a study of routine reportable matters (RRMs) for RPT operations.

5 APPENDIX A: REPORTING OF OCCURRENCES

5.1.1 Reporting requirements for all aircraft operations since 1 July 2003

Immediately Reportable Matters

IRM for all aircraft operations are:

a. subject to the exclusions in the note below, the death of, or a serious injury to:

(i) a person on board the aircraft or in contact with the aircraft, or anything attached to the aircraft, or anything that has become detached from the aircraft; or

(ii) a person who has been directly exposed to jet blast;

Note: The death of, or a serious injury to, a person does not include:

- death or serious injury resulting from natural causes (except to a flight crew member); or
- death or serious injury that is intentionally self-inflicted; or
- death or serious injury that is intentionally caused by another person; or
- death or serious injury suffered by a stowaway in a part of the aircraft that is not usually accessible to crewmembers or passengers after take-off; or
- death occurring more than 30 days after the occurrence that caused the death, unless the death was caused by an injury that required admission to hospital within 30 days after the occurrence.

b. the aircraft being missing;

c. the aircraft suffering serious damage, or the existence of reasonable grounds for believing that the aircraft has suffered serious damage;

d. the aircraft being inaccessible and the existence of reasonable grounds for believing that the aircraft has been seriously damaged;

e. breakdown of separation standards, being a failure to maintain a recognised separation standard (vertical, lateral or longitudinal) between aircraft that are being provided with an air traffic service separation service.

Note: This may result from air traffic service, pilot or other actions, and may occur even if only one (1) of the aircraft involved is under control of an air traffic service.

5.1.2 Reporting requirements for all air transport operations

Immediately Reportable Matters

IRM for all air transport operations include:

a. airprox;

b. violation of controlled airspace;

c. a near-collision involving aircraft manoeuvring on the ground;

d. an occurrence in which flight into terrain is narrowly avoided;

e. the rejection of a take-off from a closed or occupied runway;

f. a take-off from a closed or occupied runway with marginal separation from an obstacle or obstacles;

g. a landing on a closed or occupied runway;

h. a significant failure to achieve predicted performance during take-off or initial climb;

i. a fire (even if subsequently extinguished), smoke, fumes or an explosion on, or in, any part of the aircraft;

j. an uncontained engine failure;

k. a mechanical failure resulting in the shutdown of an engine;

l. the use of any procedure for overcoming an emergency;

m. an event requiring the use of oxygen by a flight crewmember;

n. malfunction of an aircraft system that seriously affects the operation of the aircraft;

o. a flight crew member becoming incapacitated during flight;

p. fuel exhaustion;

q. the aircrafts supply of useable fuel becoming so low (whether or not as a result of fuel starvation) that the pilot declares an emergency in flight;

r. undershooting, over-running or running off the side of a runway during take-off or landing, or any other similar occurrence;

s. any of the following occurrences, if the occurrence causes difficulty controlling the aircraft:

(i) a weather phenomenon; or

(ii) operation outside the aircrafts approved envelope;

t. the failure of two (2) or more related redundant systems for flight guidance and navigation; and

u. serious damage to, or destruction of, any property outside the aircraft caused by contact with the aircraft or anything that has become detached from the aircraft.

Routine Reportable Matters

RRM for all air transport operations include:

a. an injury, other than a serious injury, to:

(i) a person on board the aircraft or in contact with the aircraft or anything attached to the aircraft or anything that has become detached from the aircraft; or

(ii) a person who has been directly exposed to jet blast;

b. the aircraft suffering damage that compromises, or has the potential to compromise, the safety of the flight, but is not serious damage;

c. flight below the minimum altitude, except in accordance with a normal arrival or departure procedure;

d. a ground proximity warning system alert;

e. a critical rejected take-off, except on a closed or occupied runway;

f. a runway incursion;

g. any of the following occurrences, if the occurrence compromises, or has the potential to compromise, the safety of the flight:

(i) a failure to achieve predicted performance during take-off or initial climb;

(ii) malfunction of an aircraft system, if the malfunction does not seriously affect the operation of the aircraft;

Note: Aircraft systems include flight guidance and navigation systems.

(iii) fuel starvation that does not require the declaration of an emergency;

h. any of the following occurrences, if the occurrence compromises or has the potential to compromise the safety of the flight, but does not cause difficulty controlling the aircraft:

(i) a weather phenomenon;

(ii) operation outside the aircrafts approved flight envelope;

i. failure or inadequacy of a facility used in connection with the air transport operation, such as:

(i) a navigation or communication aid; or

(ii) an air traffic control service or general operational service; or

(iii) an airfield facility, including lighting or a manoeuvring, taxiing or take-off surface;

j. misinterpretation by a flight crewmember of information or instructions, including:

(i) the incorrect setting of a transponder code; or

(ii) flight on a level or route different to the level or route allocated for the flight; or

(iii) the incorrect receipt or interpretation of a significant radio, telephone or electronic text message;

k. breakdown of coordination, being an occurrence in which traffic related information flow within the air traffic service system is late, incorrect, incomplete or absent;

l. failure of air traffic services to provide adequate traffic information to a pilot in relation to other aircraft;

Note: The information may have been incomplete, incorrect, late or absent.

m. a traffic collision avoidance system resolution advisory being given to the pilot of the aircraft;

n. an occurrence arising from the loading or carriage of passengers, cargo or fuel, such as:

(i) the loading of an incorrect quantity of fuel, if the loading of the incorrect quantity is likely to have a significant effect on aircraft endurance, performance, balance or structural integrity; or

(ii) the loading of an incorrect type of fuel or other essential fluid, or contaminated fuel or other essential fluid; or

(iii) the incorrect loading of passengers, baggage or cargo, if the incorrect loading has a significant effect on the mass or balance of the aircraft; or

(iv) the carriage of dangerous goods in contravention of Commonwealth, State or Territory legislation; or

(v) the incorrect securing of cargo containers or significant items of cargo; or

(vi) the incorrect stowage of baggage or cargo, if the incorrect stowage is likely to cause a hazard to the aircraft or its equipment or occupants, or to impede emergency evacuation; or

(vii) a significant contamination of the aircraft structure, systems or equipment, arising from the carriage of baggage or cargo; or

(viii) the presence of a violent or armed passenger;

o. a collision with an animal, including a bird.

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