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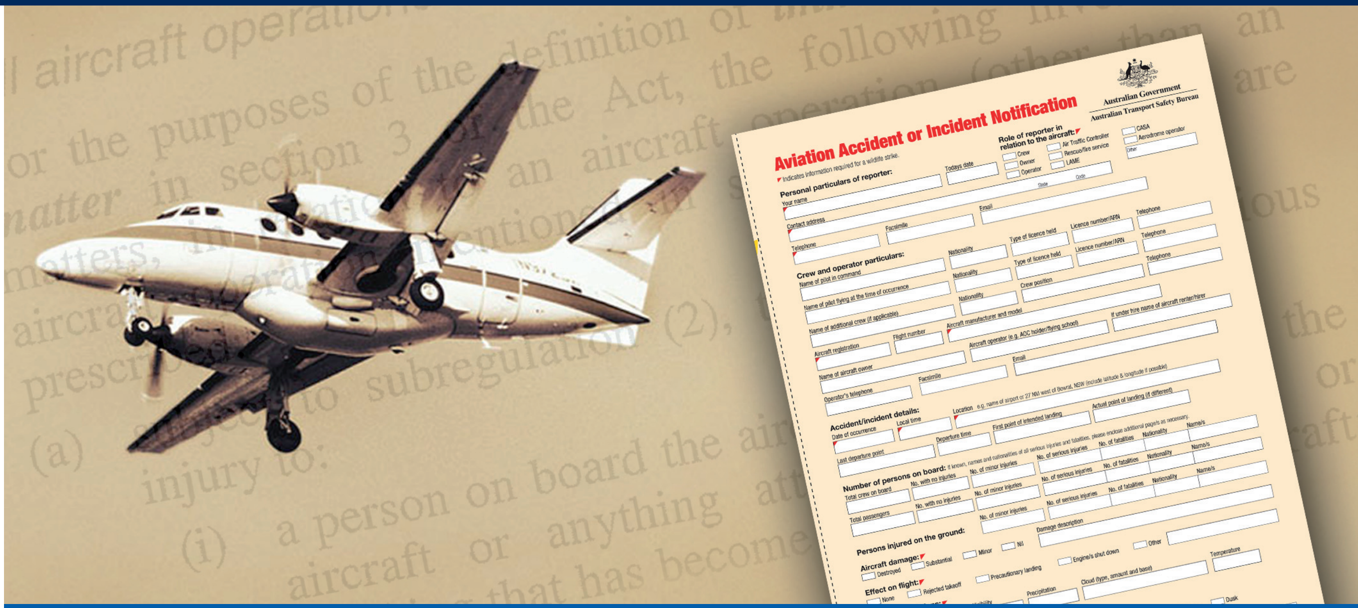

ATSB TRANSPORT SAFETY REPORT
Aviation Research and Analysis Report – AR-2007-057
Final

Trends in immediately reportable matters involving charter operations 2001 to 2006

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Trends in immediately reportable matters involving charter operations 2001 to 2006

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Abstract

This study reviewed safety trends in the Australian aviation charter industry for the period 1 January 2001 to 31 December 2006. It builds on a previous descriptive study that reviewed immediately reportable matters (IRMs) for regular public transport (RPT) aviation operations. Together, charter and RPT operations make up the air transport sector in Australia. Similar to the previous report, a subset of generally more serious IRMs were reviewed including: accidents; violations of controlled airspace (VCA); breakdowns of separation (BOS) and airproxes; fire, smoke, explosions or fumes; crew injury or incapacitation; fuel exhaustion; and uncontained engine failures. Charter flying activity, measured as flying hours and number of charter operators, was also reviewed.

Hours flown in charter operations initially declined over the study period with an increase across 2004 to 2006. However, the number of hours flown in 2006, the latest year reviewed, was not as high as the historical peak in charter hours observed in 1999. The number of charter operators decreased in 2005 and 2006, so fewer operators conducted more of the hours flown in those years.

Total IRMs reported and the IRM categories examined, were generally stable with the exception of accidents. The rate of accidents decreased significantly between 2001 and 2006. Occurrences involving fire, smoke or fumes, and airspace-related occurrences such as VCA and BOS/airprox, remained stable with no statistically significant increase in the rate across 2001 to 2006. The rate of fuel exhaustion occurrences for the period was 0.4 occurrences per 100,000 hours flown. The other IRM categories; crew injury/incapacitation and uncontained engine failures, were rare.

This review provided encouraging data on the charter accident rate, emphasised the stability of the rate of airspace related occurrences, and the rarity of uncontained engine failures and crew incapacitation in charter 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 Infrastructure, Transport, Regional Development and Local Government. ATSB investigations are independent of regulatory, operator or other external organisations.

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.

Purpose of safety investigations

The object of a safety investigation is to enhance safety. To reduce safety-related risk, ATSB investigations determine and communicate the safety factors related to the transport safety matter being investigated.

It is not the object of an investigation to determine blame or liability. However, an investigation report must include factual material of sufficient weight to support the analysis and findings. 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.

Developing safety action

Central to the ATSB's investigation of transport safety matters is the early identification of safety issues in the transport environment. The ATSB prefers to encourage the relevant organisation(s) to proactively initiate safety action rather than release formal recommendations. However, depending on the level of risk associated with a safety issue and the extent of corrective action undertaken by the relevant organisation, a recommendation may be issued either during or at the end of an investigation.

The ATSB has decided that when safety recommendations are issued, they will focus on clearly describing the safety issue of concern, rather than providing instructions or opinions on the method of corrective action. As with equivalent overseas organisations, the ATSB has no power to implement its recommendations. It is a matter for the body to which an ATSB recommendation is directed (for example the relevant regulator in consultation with industry) to assess the costs and benefits of any particular means of addressing a safety issue.

About ATSB investigation reports: How investigation reports are organised and definitions of terms used in ATSB reports, such as safety factor, contributing safety factor and safety issue, are provided on the ATSB web site www.atsb.gov.au.

EXECUTIVE SUMMARY

Background and objectives

This study reviewed safety trends in the Australian aviation charter industry. It builds on a recent study, conducted by the Australian Transport Safety Bureau (ATSB), which reviewed immediately reportable matters (IRMs) for regular public transport (RPT) operations (Australian Transport Safety Bureau, 2007b). Together, charter and RPT operations make up the air transport sector in Australia.

Charter operations involve the carriage of passengers and or cargo on non-scheduled flights by the aircraft operator or their employees for commercial reward (Bureau of Transport and Regional Economics, 2005). The purpose of charter flights can vary ranging from transporting business people and sporting teams to fly-in fly-out mining, bank or mail runs, or supply runs to remote or inaccessible communities. Charter flights can also include flying for the leisure and tourism industry including scenic or joy flights and air tours.

This report looked at trends in occurrences involving charter operations. Similar to the previous report, the generally more serious IRMs were reviewed for the purpose of identifying any trends in charter operations. Charter flying activity, measured as flying hours and number of charter operators, was also analysed.

The IRM categories reviewed in this study included: accidents; violations of controlled airspace (VCA); breakdowns of separation (BOS) and airproxes; fire, smoke, explosions or fumes; crew injury or incapacitation; fuel exhaustion; and uncontained engine failures. The study examined the period 1 January 2001 to 31 December 2006.

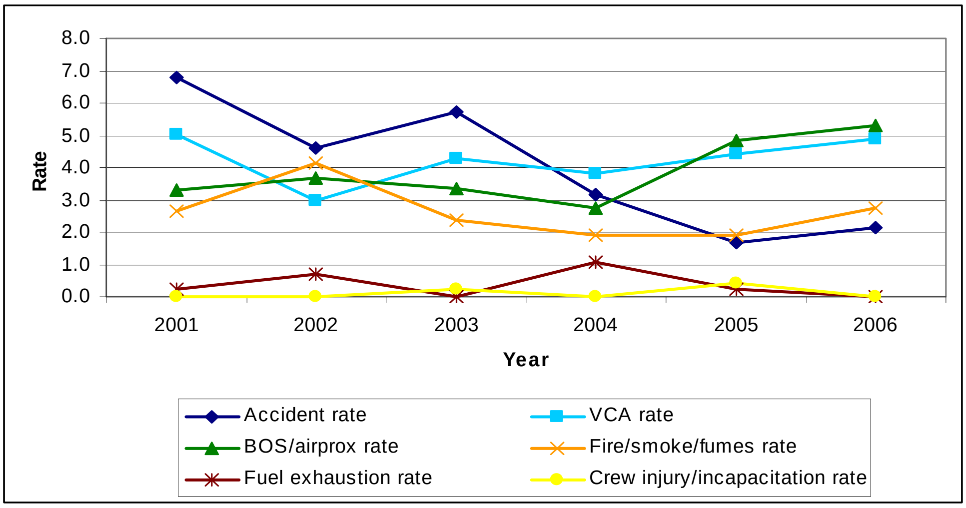
Summary of findings

The primary findings, also summarised in the figure below, are presented below.

Activity data

- The activity data showed that charter flying hours were declining but there was some increased activity in 2004 to 2006. However, the number of hours flown in 2006, the latest year reviewed, was not as high as the historical peak observed in 1999.
- The type of aircraft flying charter operations changed with more hours flown in larger, multi-engine aircraft (both fixed and rotary wing).

Summary of rates per 100,000 hours flown for each IRM group, 2001 to 2006



Accidents

- The rate of accidents involving charter aircraft displayed a downward trend. The number of fatal accidents also decreased.
- The rate of accidents decreased while the rate of incidents increased and the combined rate for all IRMs categories remained stable.
- The five most common accident categories were: mechanical problems with the aircraft's landing gear; wheels up landing; partial or complete power loss/engine failure; loss of aircraft control; and fuel-related accidents.

Violation of controlled airspace

- The rate of VCAs remained stable, with an overall rate of four occurrences per 100,000 flying hours.
- The majority of VCAs occurred in control areas (CTA), primarily Class C airspace.

Breakdown of separation and airprox occurrence

- The combined rate of BOS and airprox occurrences, comparing 2001 with 2006, did not significantly change (3.3 per 100,000 hours flown in 2001 compared with 5.3 in 2006).
- The individual rates for BOS (2.4 per 100,000 hours flown in 2001 compared with 4 in 2006) and airproxes (0.9 per 100,000 hours flown in 2001 compared with 1.3 in 2006) also did not significantly change.
- The majority of BOS occurrences occurred in CTA, primarily Class C airspace while airproxes predominantly occurred in MBZ/CTAF(R), Class G airspace.

Fire, smoke, explosion or fumes

- The rate of fire, smoke or fumes occurrences per 100,000 flying hours remained statistically stable. There were 2.6 occurrences per 100,000 flying hours in 2001 and 2.8 fire, smoke or fumes occurrences in 2006.
- Over half the occurrences involved smoke while only 13 occurrences (18 per cent) involved fire.

Fuel exhaustion

- There were 10 reported occurrences of fuel exhaustion in charter operations between 2001 and 2006 with an overall rate of 0.4 occurrences per 100,000 hours flown.

Crew injury or incapacitation

- There were only three reported occurrences of crew injury/incapacitation in the 6 years studied.

Other immediately reportable matters

- There was one incident of an uncontained engine failure in an aircraft performing charter operations during the 6-year period studied.

Conclusions

Total IRMs reported and the individual IRM categories examined, were generally stable across the period 2001 to 2006 with the exception of accidents. The rate of accidents decreased significantly from 2001 compared to 2006. Occurrences involving fire, smoke or fumes and airspace related occurrences such as VCA and BOS/airprox remained stable with no statistically significant increase in the rate. The number of occurrences involving fuel exhaustion was small and consequently variable between years. The other IRM categories; crew injury/incapacitation and uncontained engine failures, were rare.

ABBREVIATIONS

AIRPROX	Airprox is the combination of the two words, air and proximity.
AN	Air Navigation
AQIS	Australian Quarantine and Inspection Service
ATSB	Australian Transport Safety Bureau
ATC	Air traffic control
AUSSAR	Australian Search and Rescue
BITRE	Bureau of Infrastructure, Transport and Regional Economics
BOS	Breakdown of separation
CAAP	Civil Aviation Advisory Publication
CAR	Civil Aviation Regulations
CASA	Civil Aviation Safety Authority
CTA	Control area
CTAF	Common traffic advisory frequency
CTR	Control zone
ESIR	Electronic Safety Incident Report
FL	Flight level
ft	Feet
GAAP	General Aviation Aerodrome Procedures
ICAO	International Civil Aviation Organization
IFR	Instrument flight rules
IRM	Immediately reportable matters
kts	Knots
lbs	Pounds
MATS	Manual of Air Traffic Services
MBZ	Mandatory broadcast zone
NAS	National Airspace System
NM	Nautical miles (1 NM = 1.852 kilometres)
NOTAM	Notice to airmen
OAR	Office of Airspace Regulation
OCA	Oceanic areas
OCTA	Outside controlled airspace

PRD areas	Prohibited, restricted or danger areas
RPT	Regular public transport
RRM	Routine reportable matters
RVSM	Reduced vertical separation minima
SIIMS	Safety Investigation Information Management System
TAAATS	The Australian Advanced Air Traffic System
TCAS	Traffic alert and collision avoidance system
TSI	Transport Safety Investigation
VCA	Violation of controlled airspace
VFR	Visual flight rules

1 INTRODUCTION

1.1 Background

The Australian Transport Safety Bureau (ATSB) monitors aviation safety through the analysis of accident and incident data, collectively termed occurrence data, to determine whether important trends are emerging. A recent study reviewed immediately reportable matters (IRMs) for regular public transport (RPT) operations (Australian Transport Safety Bureau, 2007b). This report builds on the earlier study by reviewing IRMs for the charter industry.

The term *immediately reportable matter* was introduced in July 2003 with the commencement of the *Transport Safety Investigation Act 2003* (TSI Act) and Transport Safety Investigation Regulations 2003 (TSI Regulations). The TSI Regulations prescribe the types of occurrences which must be reported to the ATSB (see Section 1.3).

Charter operations involve the carriage of passengers and/or cargo on non-scheduled flights by the aircraft operator or their employees for commercial reward (Bureau of Transport and Regional Economics, 2005). This sector of the industry represents approximately 18 per cent of all hours flown by civil aircraft in Australia (Inglis *et al*., 2007). Together, charter and RPT operations comprise the air transport sector in Australia.

The purpose of charter flights can be quite diverse. They can include operations for corporate/business clients such as transporting business people, sporting teams, fly-in fly-out mining, bank or mail runs or supply runs to remote or inaccessible communities, or the transport of perishable goods. Charter flights can also include operations for the leisure and tourism industry such as scenic or joy flights, and air tours.

Compared to the RPT industry, there is limited published information about the charter industry. For example, there is no information available on the number of passengers transported, the amount of cargo transported domestically, or on the number of charter flights operated by the larger airlines in Australia. There is also minimal information on the number of aircraft movements (takeoffs and landings) conducted as charter.

The information that is available, both from routinely collected sources and single research projects, portrays an important industry, whose operating environment is considered quite different from, and whose safety record is perceived as less safe than, the RPT sector. Information that is routinely collected includes details of safety occurrences (by the ATSB), hours flown by charter operators (by the Bureau of Infrastructure, Transport and Regional Economics), and the number of operators certified to fly charter operations (by the Civil Aviation Safety Authority (CASA)). A review of the aviation industry from 2002 to 2006 by the ATSB (2008) showed that:

- the charter industry reported more accidents than the RPT industry;
- charter operations operated greater total hours than low capacity RPT; and
- charter operations operated fewer total hours than high capacity RPT (Australian Transport Safety Bureau, 2008).

Two reports comparing the Australian charter industry with charter industries in other countries have found that:

- the fatal accident rate per flying hours for Australia between 1995 and 2004 was lower than the equivalent rate in New Zealand (Australian Transport Safety Bureau, 2006); while
- the Australian charter accident rate was consistently higher than the United States (US) equivalent, known as Federal Aviation Regulation Part 135 non-scheduled, between 1993 and 2002 (Inglis et al., 2007). It should be noted that the hours flown by the Australian charter sector as a proportion of hours flown by all sectors was greater than the proportion flown by the US equivalent.

An ATSB survey of pilots, *Aviation Safety Survey*, found that the demographics of charter and RPT pilots differed, as did their perceptions of the hazards that threaten the safety of each sector. What did not differ between those two groups was their belief in the high level of safety of their respective sectors (Australian Transport Safety Bureau, 2004a, 2004b, 2005).

1.2 Report objective

The objectives of this report were to:

- explore trends in the reporting of IRMs for aviation charter operations from 2001 until 2006; and
- explore changes in the aviation charter environment during this time to assist the interpretation of trend data.

Similar to the *Trends in immediately reportable matters involving regular public transport operations* report, a selected group of more serious IRMs are reviewed.

1.3 Transport Safety Investigation Act

Prior to July 2003, the reporting of accidents, serious incidents and incidents involving Australian civil registered aircraft or foreign registered aircraft in Australian territory, was prescribed in Part 2A of the *Air Navigation Act 1920* (AN Act). In July 2003, Part 2A of the AN Act was repealed and the *Transport Safety Investigation Act 2003* (TSI) and Transport Safety Regulations commenced. The Transport Safety Regulations specifically lists the types of aviation occurrences, called *reportable matters*, which must be reported to the ATSB.

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

Immediately reportable matters must be reported to the ATSB as soon as reasonably practicable, by telephone, and followed by a written report within 72 hours of the occurrence. 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 separate lists of reportable matters that apply to:

- all aircraft operations;
- aircraft involved in air transport (RPT and charter) operations; and
- aircraft involved in operations other than air transport.

The IRM and RRM lists for all aircraft operations and for aircraft involved in air transport operations, as published in the Transport Safety Regulations (2003), are reproduced in Appendix B.

1.3.1 Immediately reportable matters

The ATSB received only a small number of reports for many types of IRMs, making a meaningful analysis of reporting trends for all occurrence types across the time period impossible. Therefore, this report focuses on the more common occurrences that were reported under both the AN Act and the TSI Act. The following types of IRMs are examined in this report:

- accidents
- violations of controlled airspace
- breakdown of separation and airprox occurrences
- fire, smoke, explosion or fume occurrences
- crew injury or incapacitation
- uncontrolled engine failures
- fuel exhaustion occurrences.

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.

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 (VCA)

Civil airspace in Australia is classified, with minor variations, in accordance with the International Civil Aviation Organization (ICAO) Airspace Classification system as documented in the Australian Airspace Policy Statement. It can be broadly divided into two categories, controlled and uncontrolled.

Controlled airspace is a generic term which, in Australia, covers Air Traffic Services (ATS) airspace classes A, C, D and E, and control zones in which General Aviation Aerodrome Procedures (GAAP) are used. Class G airspace is uncontrolled. Controlled airspace is established generally on the basis of traffic density and substantial RPT turbo-jet operations and considerations of flight procedures (Airservices Australia, 2007).

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, 2003a).

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.

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 altitude 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, 2003a). Clearances are required for all aircraft flying under instrument flight rules (IFR) to enter Class A, C, D and E, and required for aircraft flying under visual flight rules (VFR) entering Class C or D (Airservices Australia, 2007).

Some airspace is also classified as prohibited, restricted or danger (PRD) areas. 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). Non-military airspace can also be designated a restricted area, such as the airspace around the Lucas Heights nuclear reactor. The only prohibited airspace in Australia is associated with the Joint Defence Facility at Pine Gap. Danger areas identify potential hazards (for example, the location of parachuting operations), but entry into this airspace does not require a clearance.

Prohibited, restricted or danger areas can be permanently activated, activated routinely at specified times, or activated temporarily by a notice to airmen (NOTAM) (Airservices Australia, 2007).

A *violation of controlled airspace* (VCA) 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 or prohibited area without a clearance is also recorded as a VCA.

Breakdown of separation (BOS) and airprox

Separation standards are applied in Australian airspace to keep aircraft at a specified distance from other aircraft to minimise 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, 2003a). The type of standard in place is determined by air traffic control and is based on the environment and circumstances at the time (Airservices Australia, 2003a).

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. Charter flights operate under both IFR and VFR in controlled and uncontrolled airspace and fly into a range of aerodromes from major airports to private, dirt landing areas.

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[1] (Airservices Australia, 2003a). Vertical separation means that aircraft would not generally come closer than 1,000 ft.

Longitudinal separation is applied between aircraft travelling on the same or reciprocal direction tracks[2] and is based on either time or distance (Airservices Australia, 2003a).

Lateral separation is the minimum distance between aircraft in the lateral plane (wing tip to wing tip). 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 distance (usually 1 NM), (Airservices Australia, 2003a).

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, 2003a). 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 Regulations define a *breakdown of separation* (BOS) as a failure to maintain a recognised separation standard (vertical, lateral or longitudinal) between aircraft that are being provided with an ATC 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 is under the control of an air traffic service. For air transport aircraft, a separation standard is provided in controlled airspace at least between IFR aircraft.

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[1] 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. It reduces the minimum vertical separation from 2,000 ft to 1,000 ft.

[2] Same or reciprocal direction tracks intercept at less than 45 degrees (Airservices Australia & Department of Defence, 2008).

An *airprox* is defined in the TSI Regulations 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. A fire or an explosion in an aircraft poses a serious risk to the lives of crew and/or passengers and, in most circumstances, requires landing the 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 injury or illness of the flight crew. Incapacitation or injury of a pilot is a significant threat to the safety of the aircraft and its occupants.

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 are considered a contained engine failure.

Fuel exhaustion

The TSI Regulations define fuel exhaustion as when an aircraft has exhausted its useable fuel.

The CASA 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) 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 239).

1.4 Changes in the charter operating environment

The past two decades have seen many significant changes in the operating environment for the charter industry and in general aviation (GA) (General Aviation Action Agenda Strategic Industry Leaders Group, 2008). The changes experienced by charter operators can be broadly classified into four areas: business environment, aircraft, regulation and airspace reform.

Business environment

The business environment for charter operators appears to have polarised with a widening gap between small and large operators. There has been a growth in flying contracts, especially to provide fly-in fly-out services to the mining industry, which has seen a change in the operating environment with the emergence of larger operations and more sophisticated business models. The aircraft charter contracts with the mining industry generally specify aircraft and crew requirements that involve the use of modern, turbine-powered jet aircraft operated by more than one crew member (Milne, 2008; Skywest Airlines, 2008). Those charter operations contrast with the smaller operators flying three or less small, piston-engine aircraft with generally more ad hoc contractual arrangements.

Over the past 10 years, the business costs of charter operations have increased (Bureau of Transport and Regional Economics, 2005). Those costs include purchasing aircraft, acquiring type-certified spare parts, fuel, aviation security requirements, cost recovery by the regulator, and airport costs. At the same time, the competition from alternative transport options has become greater with lower fares for scheduled flights and improvements in roads and the safety and comfort of road vehicles (Bureau of Transport and Regional Economics, 2005). The availability of pilots and licensed aircraft maintenance engineers may also affect the business costs of charter operators in the future and has probably already impacted some operators (General Aviation Action Agenda Strategic Industry Leaders Group, 2008). The shortage of both pilots and aircraft maintenance engineers may put pressure on profitability (CASA, 2008) through increasing operational costs.

A further change in the business environment of charter operators has been the variation in supplementary flying operations. Aircraft that are used for charter operations, if appropriately certified, can also be used to perform other flying operations such as flying training or aerial work. The amount of aerial work or agriculture-related work has been affected by the drought on the Australian east coast and the resources boom on the west coast. The growth of recreational flying in ultralight aircraft has also reduced the amount of flying training work for type certified aircraft (Bureau of Transport and Regional Economics, 2005; General Aviation Action Agenda Strategic Industry Leaders Group, 2008).

Aircraft fleet

The size and age of aircraft flying charter operations has also changed. Like the business environment, the type of aircraft performing charter operations is diverging. At one end of the continuum are the smaller, ageing, piston and turboprop-engine aircraft while at the other end are the turbine-powered jets which are both larger and on average, younger (Australian Transport Safety Bureau, 2007a). The single-engine piston aircraft continue to perform the more traditional charter flights while the larger jets are increasingly being used to fly ‘closed’ charter flights where organisations contract operators to transport employees and/or cargo on a fixed schedule to a fixed destination. The ageing, piston-engine aircraft have increasing maintenance costs and some are proving difficult to replace with similar sized newer aircraft. The larger, newer aircraft are providing more modern avionics and greater payloads (Bureau of Transport and Regional Economics, 2005). Despite the growth in activity performed by jet aircraft, the majority of charter flying activity continues to be performed by piston and turboprop-engine aircraft (Bureau of Transport and Regional Economics, 2006).

Regulatory framework

Between 2001 and 2006, a number of regulatory changes directed at charter operations were commenced. The Civil Aviation Safety Authority began the redevelopment of civil aviation regulations to bring the regulatory requirements of passenger charter flights in line with RPT operations (CASA, 2003). This new civil aviation safety regulation (CASR) is still under development at the time of publishing, but communication about the changes have indicated that the new CASR will introduce more comprehensive training and checking requirements, including crew resource management training, and expand aeroplane performance requirements for charter operators (CASA, 2003).

Airspace changes

Australian airspace underwent significant reform between 2002 and the end of 2005. Known as the National Airspace System (NAS), the reforms 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, 2007). The then Department of Transport and Regional Services[3] 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, such as access to radar based information services;
- lowering the base of Class A airspace to 18,000 ft in areas with radar coverage;
- a proportion of en route Class C airspace was changed to Class E;
- an expansion of mandatory transponder carriage to include all aircraft operating above 10,000 ft; and
- the introduction of standardised operating procedures at all non-towered aerodromes (Department of Transport and Regional Services, 2007).

In July 2007, the Office of Airspace Regulation (OAR) was established within CASA to regulate airspace under Airspace Regulations 2007. The OAR has responsibility for the regulation of airspace in accordance with the Australian Airspace Policy Statement.

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 from Class C to E airspace.

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[3] The Department of Transport and Regional Services was renamed the Department of Infrastructure, Transport, Regional Development, and Local Government in December 2007.

2 METHODOLOGY

2.1 Data sources

This study is based on analysis of occurrences reported to the Australian Transport Safety Bureau (ATSB) for the 6-year period 1 January 2001 to 31 December 2006. The following types of immediately reportable matters (IRMs) were analysed over the defined period to identify any observable safety trends:

- accidents;
- violation of controlled airspace occurrences;
- breakdown of separation and airprox occurrences;
- occurrences involving fire, smoke, explosion or fumes;
- fuel exhaustion occurrences;
- crew injury or incapacitation occurrences; and
- uncontained engine failures.

The definitions for each of these IRM categories can be found in Section 1.3.1.

The categories of IRMs chosen for analysis were occurrences that were required to be reported under both the *Air Navigation Act 1920* and the *Transport Safety Investigation Act 2003*. This minimised the potential for the change in legislation to influence the reporting of these occurrences.

Occurrence data

The occurrence data was sourced from the ATSB aviation occurrence databases known as OASIS and SIIMS (Safety Investigation Information Management System).[4] A search of the OASIS database was conducted to identify occurrences involving Australian civil registered (VH-) and foreign registered aircraft conducting charter operations within Australian territory. A search of SIIMS was conducted to identify all IRM occurrences that occurred between 2001 and 2006.

The extracted data was reviewed and further sorted into the sub-categories presented in the report. A list of definitions of the occurrence types presented in the section on reportable accidents is included in Appendix C.

Flying-hours data

Australian flying-hours data were provided by the Bureau of Infrastructure, Transport and Regional Economics. This information was collated from responses to the annual *General Aviation Activity Survey*. This survey collected data from the general aviation industry, which covers VH-registered aircraft conducting non-scheduled flying activity and aircraft used by regional airlines. This survey was not distributed to the major regular public transport (RPT) airlines and as such did not collect data on the charter flying hours performed by major RPT airlines.

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[4] In April 2007, SIIMS replaced OASIS as the ATSB's aviation occurrence database.

The flying hour data used in this report includes fixed and rotary wing aircraft but excludes balloons.

Movement data (the number of takeoffs and landings) for charter flights was not collected as part of the *General Aviation Activity Survey*. The purpose of the flight, that is, movement of passengers or freight, was also not recorded in the survey.

2.2 Analyses conducted

The number of recorded events for each type of IRM and flying hours for charter flights were grouped into calendar years and graphed. The rates for each of the IRM categories were also calculated and graphed. Rates were calculated as occurrences per 100,000 flying hours. The rate data provides a more informative indicator of change over time than the number of occurrences as it takes into account any change in the activity level across the years. Where there was sufficient data, a generalised linear regression analysis[5], either Poisson regression, regression assuming a negative binomial distribution, or ordinary least squares regression[6] was used to determine if there was a statistically significant change in the occurrence rate.

Since the flying hours data only included VH-registered aircraft from operators other than the major airlines, the rate data reported includes only occurrences that involved VH-registered aircraft and were not operated by one of the major airlines. If any IRM category involved occurrences from foreign registered aircraft or aircraft operated by a major airline, this is stated in the report.

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[5] Generalised linear regression is a statistical model, one of the family of generalised linear models, that can be used to analyse data where the response variable is discrete, skewed and or non-linearly related to the explanatory variables (Hutcheson & Sofroniou, 1999).

[6] Ordinary least squares regression was selected over other methods as the mean number of occurrences was greater than 10 and the variability in flying hours between the different years was limited.

3 RESULTS AND DISCUSSION

This chapter presents data on charter flying hours, the types of aircraft performing charter operations, the number of charter operators, trends in selected immediately reportable matter (IRM) categories, and discussion of the findings.

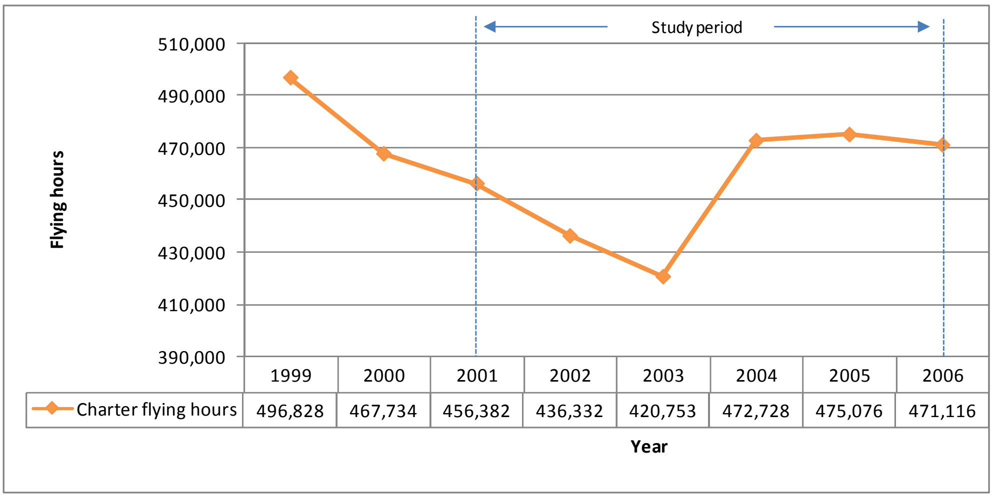
3.1 Flying hours

Flying hours performed in charter operations were included as an indicator of activity over the period of interest. Between 2001 and 2003, charter hours declined an average of four per cent each year. This trend reversed after 2003 with a 12 per cent increase in charter flying between 2003 and 2004. Following this jump, charter flying hours remained steady, at around 470,000 hours annually.

Figure 1 below indicates that there has been growth in charter flying hours over the study period (2001 to 2006). The selection of 2001 as the base year influences this interpretation. The linear trend in flying hours, using 1999 as the comparison year (496,828 hours), decreased with flying hours not returning to the peak level seen in 1999.[7]

The growth in hours between 2003 and 2004 may reflect activity associated with the resources boom.

Figure 1: Hours flown during charter operations, 1999 to 2006



	1999	2000	2001	2002	2003	2004	2005	2006
Charter flying hours	496,828	467,734	456,382	436,332	420,753	472,728	475,076	471,116

3.1.1 Flying hours by aircraft type

The majority of charter flying hours were performed by fixed-wing, multi-engine aircraft, followed by fixed-wing, single-engine aircraft, single-engine helicopter, and multi-engine helicopters, respectively. The distribution of charter hours by aircraft type is presented in Figure 2.

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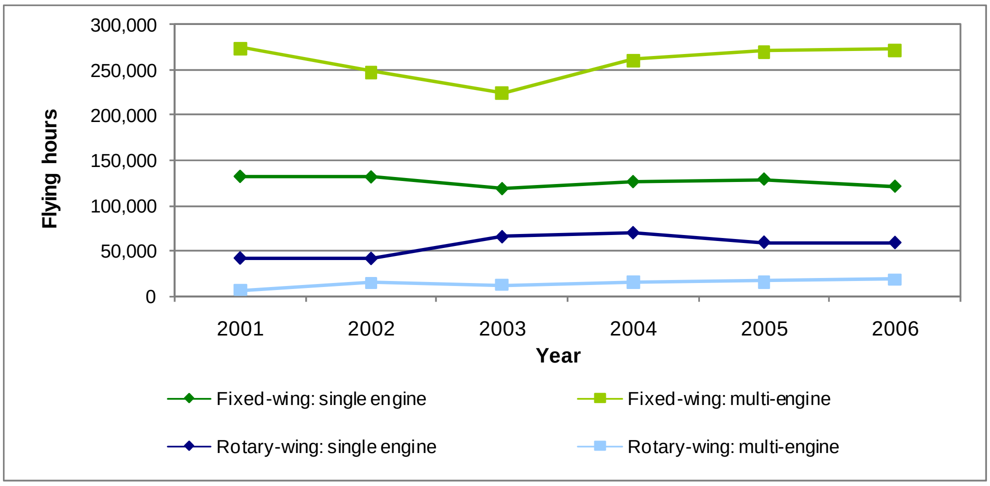
[7] The latest data published by BITRE indicates that charter operators flew 536.4 thousand hours in 2007. This figure is higher than the previous historical peak recorded in 1999.

Figure 2 indicates that there was a change in the type of aircraft performing charter operations with growth in the hours flown by larger multi-engine aircraft and a decline in smaller fixed-wing aircraft.

Hours flown by single-engine fixed-wing aircraft dropped by eight per cent between 2001 and 2006.

Figure 2: **Hours flown by aircraft type and number of engines, 2001 to 2006**

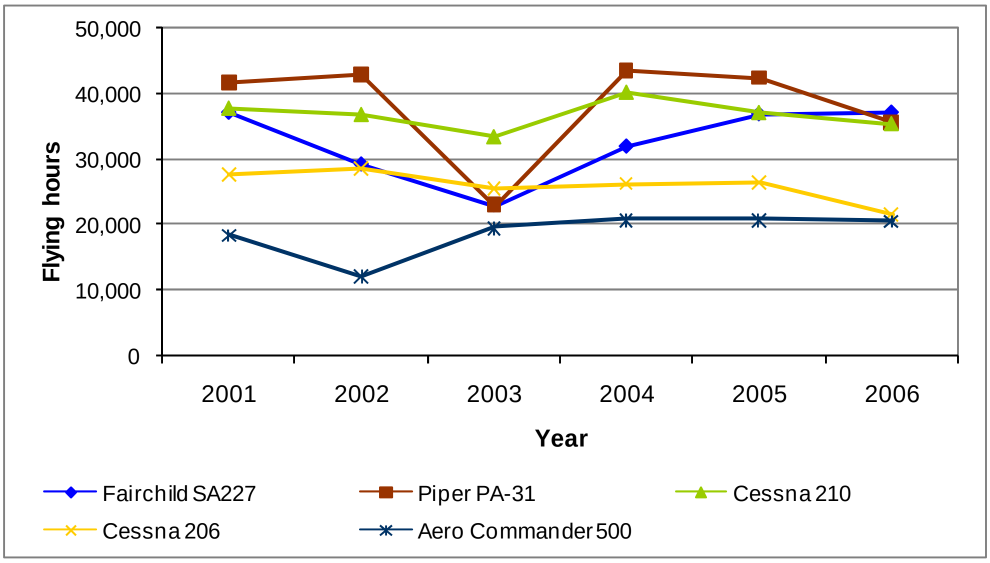


3.1.2 Flying hours by aircraft model

The top five fixed-wing aircraft models flying charter in Australia in 2006 were the Fairchild SA227 (Metro III and Metro 23), Cessna 210 (Centurion), Piper PA-31 (Navajo, Mojave and Chieftain), Cessna 206, and Aero Commander 500 (see Figure 3). Until 2006, the Piper PA-31 (twin-engine piston aircraft with seating of up to nine passengers) was the dominant fixed-wing aircraft used for charter operations across the period. However, by 2006, the Fairchild SA227 (a twin-engine turboprop aircraft with a seating capacity of up to 19 passengers) and Cessna 210 (a single-engine piston aircraft with seating of up to five passengers) were as commonly used for charter operations as the Piper PA-31 aircraft.

The Cessna 206 (a single piston-engine aircraft with up to five passengers) and Aero Commander 500 (a twin-engine piston aircraft with up to six passengers) flew less charter hours than the above three aircraft by 2006. The charter hours flown by the Cessna 206 consistently declined over the years studied.

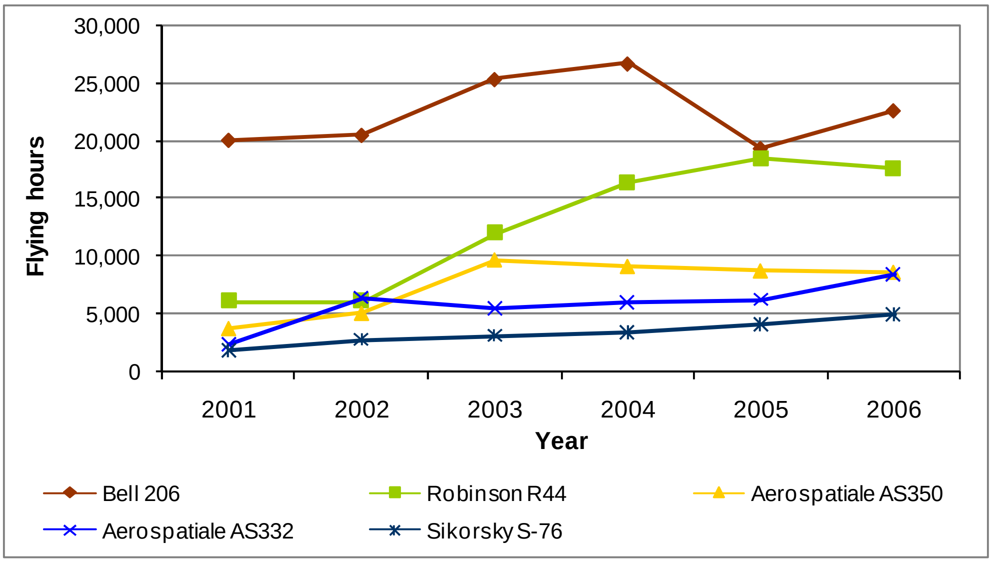
Figure 3: Hours flown by aircraft model (fixed-wing), 2001 to 2006



For rotary-wing aircraft, the top five aircraft models flying charter in 2006 were the Bell 206 (JetRanger), Robinson R44, Aerospatiale/Eurocopter AS350 (Ecureuil) and AS332 (Super Puma), and Sikorsky S-76 (see Figure 4). The Bell 206 (a single-engine turboshaft with maximum of five passengers) flew the most hours in charter operations each year between 2001 and 2006 while the popularity of the Robinson R44 (a piston-engine aircraft with a maximum of three passengers) grew steadily over the six years, flying nearly three times more hours in 2006 than in 2001.

Although flying considerable lower charter hours, there was some increase in the hours flown across the six years by the two larger and twin-engine turboshaft helicopters, the AS 332 (capacity of 17 passengers) and S-76 (capacity of 13 passengers).

Figure 4: Hours flown by aircraft model (rotary-wing), 2001 to 2006



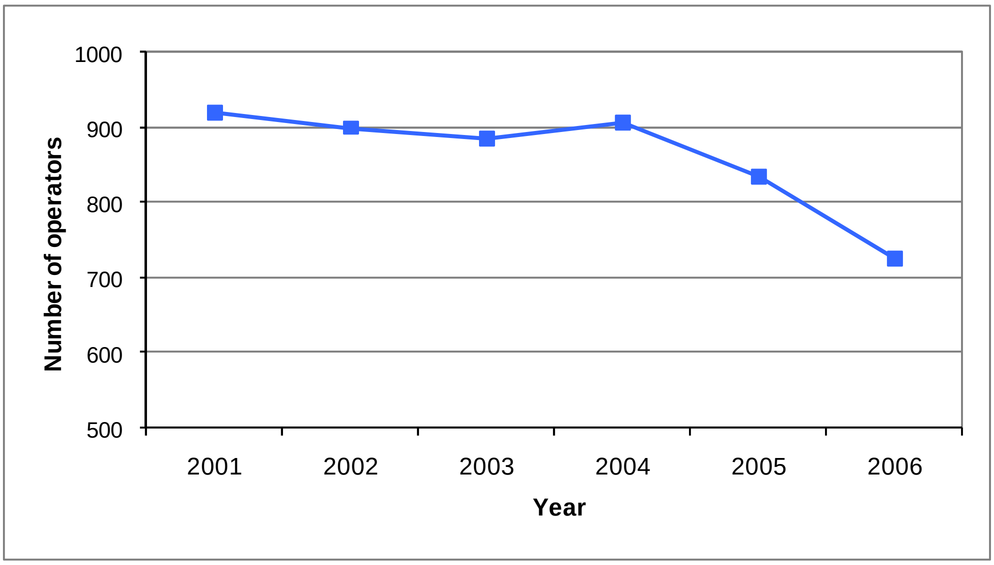
Aircraft such as the Fairchild Metro have typically been used for low capacity regular public transport (RPT) operations, particularly by regional airlines. The growing popularity of using larger aircraft for charter reflects the changing nature of the industry with a move towards scheduled charter operations, often referred to as 'closed' charter operations. This is where organisations contract airlines to transport employees and/or cargo on a fixed schedule to and from fixed destinations. For example, Skywest Airlines recently announced the signing of a scheduled charter contract with the Fortescue Metals Group to transport production workers between Perth and Fortescue's Cloudbreak mine site in Western Australia. The 'fly-in fly-out' passenger service was to be conducted six or more times each week using Skywest's Fokker 100 aircraft, which has a seating capacity of 100 (Skywest Airlines, 2008).

Aircraft used in charter operations are generally also used for other flying operations. Between 2001 and 2006, aircraft flying charter operations were also used for, in descending order, flying training, regional RPT, aerial work, private, business and agriculture operations.

3.2 Number of operators

Figure 5 shows that the number of separate operators that conducted at least one hour of charter operations declined between 2001 and 2006. This data, like the flying hours data, was extracted from responses to the General Aviation Activity Survey. The number of unique operators with at least one aircraft was counted for each year. Comparing this data with hours flown (Section 3.1) indicates that in the later years, fewer operators conducted more of the hours.

Figure 5: Number of operators whose aircraft flew charter hours, 2001 to 2006



Note: this data excludes operators of airships, balloons, amateur built aircraft, and major domestic airlines.

As previously mentioned, alternative measures of activity such as aircraft movements or passengers carried has not been routinely collected.

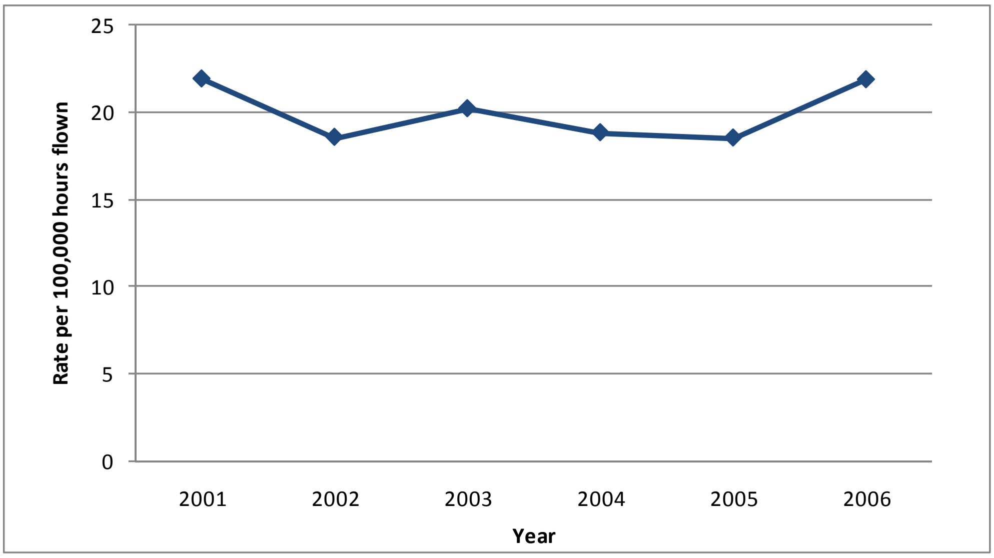
3.3 Trends in immediately reportable matters

3.3.1 All immediately reportable matters involving charter operations

Figure 6 presents the trend for all immediately reportable matters (IRMs) involving charter operations as a rate per 100,000 hours flown. The data was selected according to the occurrence type, level of injury to persons, and level of damage to the aircraft. A list of all the IRM categories is provided at Appendix B.

The overall rate of combined IRMs was 20 occurrences per 100,000 hours flown. This rate has been relatively stable between 2001 and 2006 with only small variations between years. Statistical analysis confirmed that there was no significant trend in the rate of all IRMs over the time period.[8]

Figure 6: Rate of all IRMs involving charter operations, 2001 to 2006



The combined rate of IRMs was included as a reference point for changes in individual IRM categories. The individual IRM categories reviewed in this report include 109 accidents, 122 violations of controlled airspace, 78 breakdowns of separation or airproxes, 71 occurrences involving fire, smoke or fumes, 10 fuel exhaustion occurrences, three crew incapacitation occurrences, and one uncontained engine failure. The following sections explore trends in those IRM categories.

3.3.2 Reportable accidents

There were 109 accidents involving aircraft flying charter operations between January 2001 and December 2006. Only one of those accidents involved a non-VH-registered aircraft. Figure 7 below shows there was a noticeable downward trend in the number of accidents reported in charter operations. The rate of accidents per 100,000 flying hours also reflected this trend, dropping by 30 per cent between 2001 and 2006. This was a statistically significant decrease in the rate of accidents.[9]

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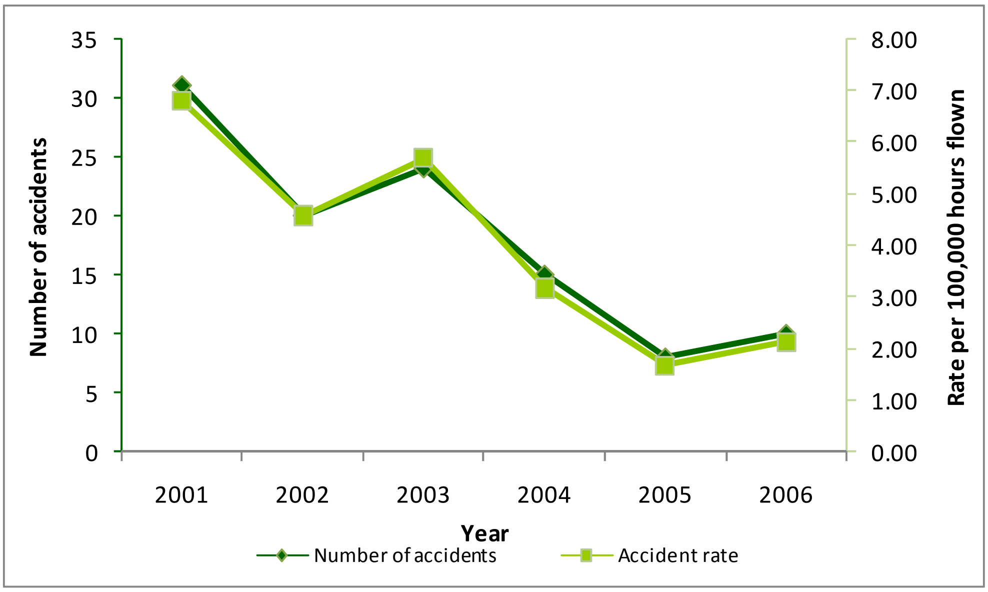
[8] Ordinary least squares regression (t = -0.1, p = 0.9).

[9] Poisson regression ($\chi^2 = 10.2$, $p \leq 0.001$).

Figure 7: Accidents and accident rate per 100,000 hours flown (VH-registered aircraft), 2001 to 2006



Of the 108 accidents, 12 were fatal (11 per cent), three resulted in serious injury (3 per cent), and 14 resulted in minor injuries (13 per cent). The remaining 79 accidents (73 per cent) resulted in nil injuries, however, aircraft damage was recorded. The number of fatal accidents each year has dropped from four in 2001 to one in 2005 and 2006. In 2004, there were no fatal accidents involving charter operations.

Rate of accidents and incidents

As previously stated, accidents 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. They also include missing aircraft, and the aircraft suffering serious damage. In contrast, an incident is an occurrence, other than an accident, associated with the operation of an aircraft that affects or could affect the safety of operation (Australian Transport Safety Bureau, 2008).

Figure 8 indicates that while the rate of accidents involving charter operations decreased over the study period, the rate of incidents reported to the ATSB increased from 79 per 100,000 hours flown in 2001 to 125 per hours flown in 2006. This was a statistically significant increase in the rate of incidents.[10] This increase in the rate of incidents from 2003 was probably the result of an increase in reporting due to the introduction of the *Transport Safety Investigation Act 2003* (TSI Act) and Transport Safety Investigation Regulations 2003 (TSI Regulations) in mid 2003. The TSI Regulations better specified a comprehensive range of incidents that are required to be reported to the ATSB. Figure 8 also demonstrates the greater number of incidents reported relative to accidents with an overall rate of approximately four accidents per 100,000 hours flown compared to 100 incidents per 100,000 hours flown.

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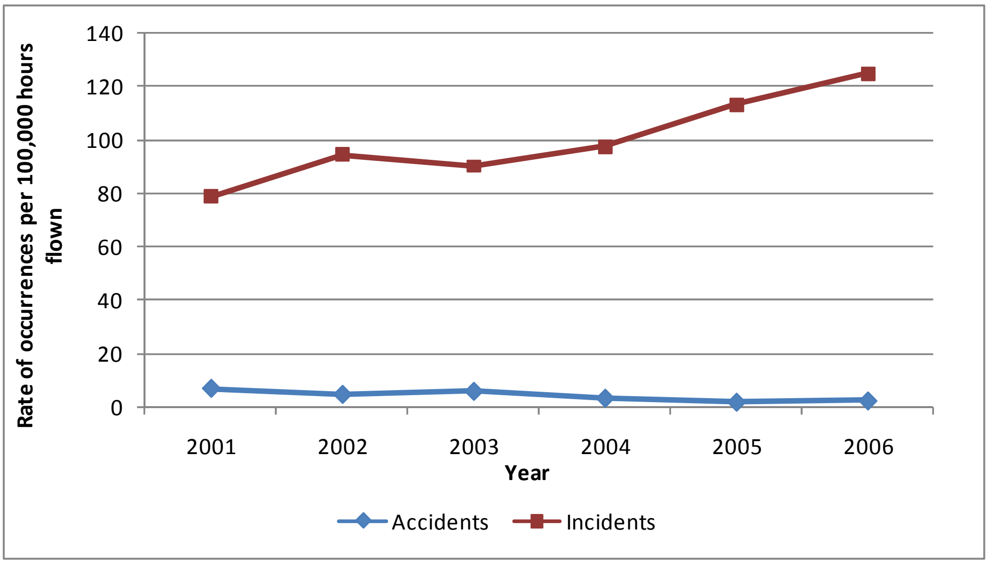
[10] Ordinary least squares regression ($t = 5.9$, $p < 0.01$).

Figure 8: Rate of accidents and incidents involving charter operations, 2001 to 2006



Accident occurrence types

Table 1 and Figure 9 summarise the type of accidents that occurred during charter operations over the time period. Each accident was categorised into one occurrence type. While it is possible, but not necessarily common, for one accident to be classified into multiple occurrence categories, only the primary type of occurrence[11] was selected in this study.

To assist in the presentation of the data, Figure 9 collapses a number of the occurrence categories listed in Table 1. The five most common accident categories were: mechanical problems with the aircraft's landing gear (20 per cent), wheels-up landing (12 per cent), partial and complete power loss/engine failure (14 per cent), loss of aircraft control (11 per cent), and fuel-related accidents (7 per cent).

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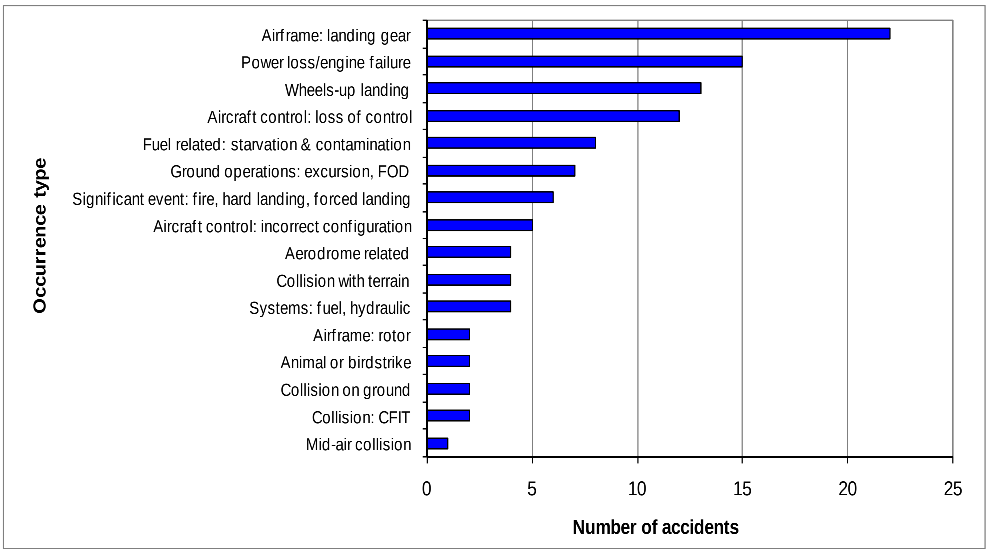
[11] The primary occurrence type is the key or pivotal event in the occurrence sequence. It is usually the single event that best describes what happened in the occurrence.

Table 1: Charter accidents by occurrence type, 2001 to 2006

Occurrence type	Fatal	Injury	Aircraft damage	Total
Airframe: landing gear	0	0	22	22
Engine power loss: engine failure	3	2	8	13
Wheels-up landing	0	0	13	13
Aircraft control: loss of control	4	2	6	12
Fuel related: starvation	1	3	3	7
Aircraft control: incorrect configuration	0	1	4	5
Ground operations: excursion	0	3	2	5
Aerodrome related	0	1	3	4
Collision with terrain	2	0	2	4
Significant event: hard landing	0	0	3	3
Airframe: rotor	0	2	0	2
Collision on ground	0	0	2	2
Collision: controlled flight into terrain (CFIT)	2	0	0	2
Engine power loss: partial	0	1	1	2
Systems: fuel	0	0	2	2
Systems: hydraulic	0	1	1	2
Animal strike	0	0	1	1
Birdstrike	0	0	1	1
Fuel related: contamination	0	1	0	1
Ground operations: foreign object damage	0	0	1	1
Ground operations: other	0	0	1	1
Mid-air collision	0	0	1	1
Significant event: fire	0	0	1	1
Significant event: forced landing	0	0	1	1
Significant event: other	0	0	1	1
Total	12	17	80	109

Note: A list of definitions for each of the above occurrence types is provided at Appendix C.

Figure 9: Charter accidents by occurrence type, 2001 to 2006



Three of the accidents listed above are also included in other IRM sections of this report: one accident that was also categorised as a fuel exhaustion occurrence, and two accidents that involved fire.

There are a number of notable characteristics of the accidents in charter operations. Collisions, loss of control and power loss occurrences were more likely to result in fatal outcomes. The most common occurrence type was wheels-up landings due to either mechanical problems with the landing gear or landing with the landing gear retracted. Also of note was the number of fuel-related occurrences, an occurrence type that can have severe consequences. It is possible that some of the power loss occurrences, where the reasons for the loss of power was unknown, were also fuel-related further increasing the frequency of those occurrences.

Summary

In summary, the rate of charter accidents has reduced between 2001 and 2006. This decrease in the accident rate occurred while the rate of all IRMs remained stable, however, the total incident rate increased. A reduction in wheels-up landings would provide the largest opportunity to improve the accident rate while a reduction in collision and loss of control occurrences would reduce the number of more severe accidents.

Summaries of several accidents are presented below.

Accidents

Wheels-up landing (Occurrence number 200303618)

The aircraft, a Cessna 210 with five people on board, landed with the landing gear retracted. The pilot reported that she may have been distracted during the approach by abnormal traffic and the presence of a strong crosswind. There were no reported injuries.

Collapsed landing gear (Occurrence number 200503139)

On 02 July 2005 at about 0920 Eastern Standard Time, the pilot of a Piper PA-32RT-300 aircraft conducted pre-flight checks. Five passengers and the pilot boarded a local scenic flight from Townsville Airport, Qld.

During the take-off roll, the pilot noticed an object go past the windscreen. He rejected the takeoff and returned to the apron. The pilot found that the engine cowling bungs had not been removed during the pre-flight. He then removed the bung material from the cowl openings.

The pilot and passengers then departed for the scenic flight. The aircraft radio failed. The pilot contacted the aerodrome controller by mobile telephone and obtained approach and landing instructions. He selected the aircraft's landing gear down but the gear position lights did not illuminate as the electrical system had failed. The pilot extended the landing gear in accordance with the emergency procedures checklist.

The right main landing gear collapsed during the landing roll and then the left main and nose landing gears collapsed. Due to the damage to the aircraft, the investigation was unable to establish the reason for the right main landing gear collapse.

Fuel starvation (Occurrence number 200105446)

The pilot of the Cessna 210 declared a MAYDAY and stated that he had lost engine power and was attempting a landing on a road. A short time later, the aircraft impacted heavily in a left-wing low, nose-down attitude on lightly wooded scrub ground to the south of the road. The pilot received fatal injuries. The three passengers were transported to hospital with serious injuries.

The afternoon before the flight, the operator requested fuel for the aircraft (160 litres in each of two tanks) but later amended the requirement to fill the fuel tanks to a new quantity of 120 litres in each tank. The trip fuel log found in the aircraft revealed that the pilot had entered the incorrect fuel total with annotations of 160 litres per fuel tank instead of the actual 120 litres per fuel tank. Because of the initial fuel total error, the pilot would have expected to have 40 litres more remaining in each tank at the time the engine lost power.

Only unusable fuel was found in the left fuel tank while the contents of the right fuel tank were observed to have leaked during the passenger rescue. The wreckage, engine and component examinations found no evidence of pre-existing mechanical defects with the aircraft or its systems that would have prevented normal aircraft operation prior to the accident.

In the absence of evidence of a mechanical failure leading to engine loss of power, the most likely cause of the engine loss of power was associated with fuel supply starvation or interruption.

3.3.3 Violation of controlled airspace (VCA)

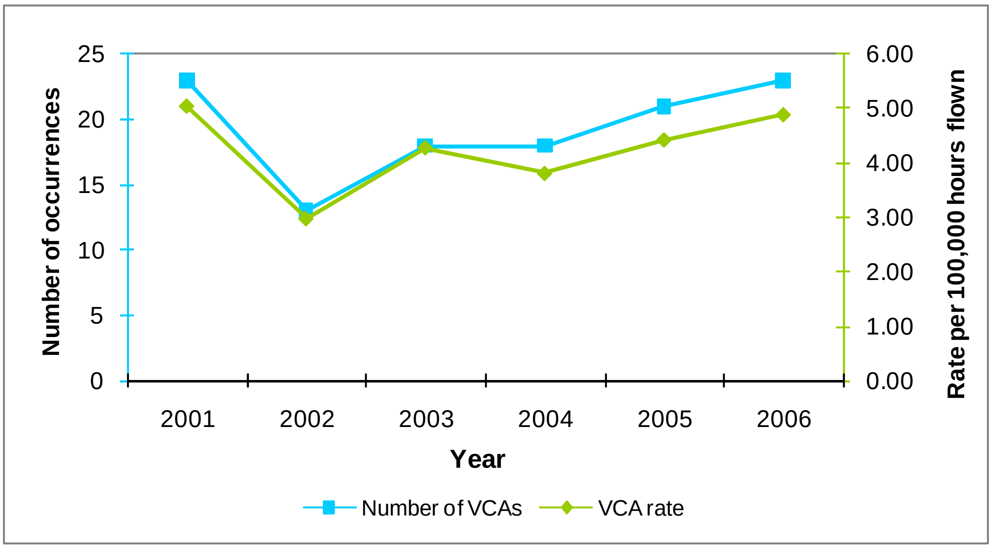
Aircraft performing charter operations were involved in 122 violation of controlled airspace (VCA) occurrences between 2001 and 2006 ranging from 13 occurrences in 2002 to 25 occurrences in 2006 (see Table 2). Of those 112 occurrences, 95 per cent involved Australian civil registered aircraft (VH-), while the remaining five per cent involved foreign-registered aircraft.

Table 2: Violation of controlled airspace occurrences during charter operations, 2001 to 2006

Year	All aircraft	VH-registered aircraft only
2001	23	23
2002	13	13
2003	18	18
2004	20	18
2005	23	21
2006	25	23
Total	122	116

The number and rate of VCA occurrences, involving VH-registered aircraft is presented in Figure 10 below. The highest number of VCAs involving charter aircraft occurred in 2001, with 23 occurrences recorded. This decreased to 13 in 2002, but has since increased to the 2001 level. When taking into account activity, the rate of VCA occurrences per 100,000 flying hours has remained stable over the period studied[12] with the exception of 2002 where a decline was recorded.

Figure 10: Number and rate of VCAs for VH-registered aircraft performing charter operations, 2001 to 2006



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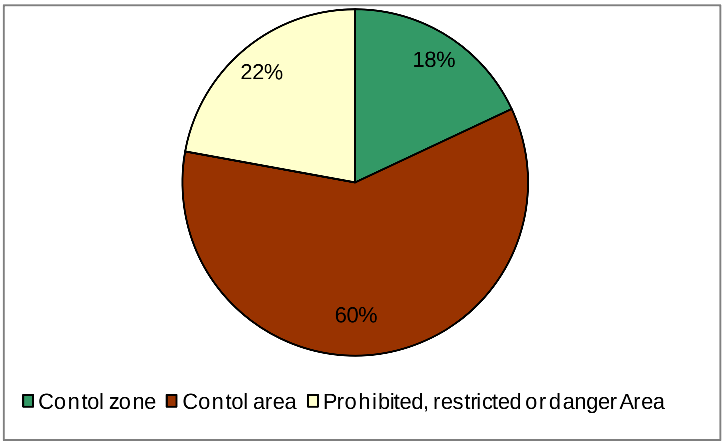
[12] Poisson regression determined that the rate of VCAs had not significantly changed over the period 2001 to 2006 ($\chi^2 = 0.01$, p = 0.91).

Of the 122 VCA occurrences, six (5 per cent) resulted in a breakdown of separation with another aircraft. Sixty per cent of the VCA events occurred when the aircraft was operating under instrument flight rules (IFR).

Airspace class and type

Figure 11 shows the type of airspace where most VCAs occurred. Entry without a clearance into controlled airspace other than an airport control zone (Control area) was the most frequent VCA event. Entry into restricted or prohibited airspace was the next most common followed by entry into the control zone around an airport without a clearance.

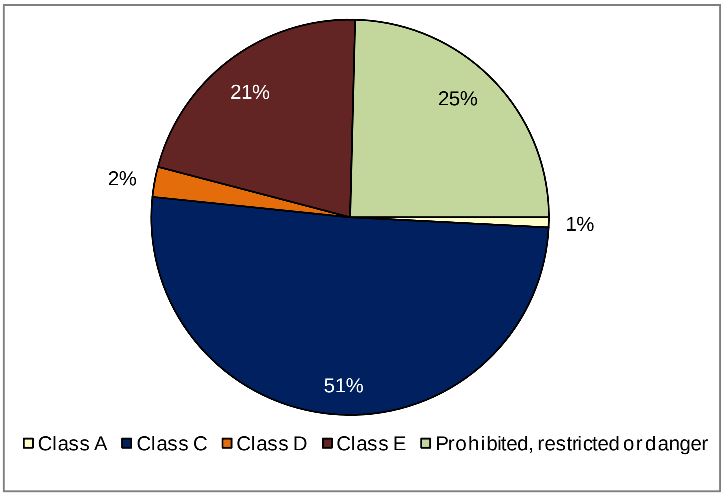
Figure 11: VCAs by airspace type, 2001 to 2006



Note: Refer to Appendix D for definitions of airspace type.

Figure 12 summarises the class of airspace where charter VCAs occurred. The most common airspace class involved was Class C airspace, accounting for half of the VCA occurrences involving charter aircraft. This was followed by Class E accounting for one-fifth of VCAs. Both Class D and A airspace recorded a small number of VCAs (two and one per cent respectively). Prohibited, restricted or danger (PRD) areas do not have a designated class of airspace but are included here to complete the picture.

Figure 12: VCAs by airspace class, 2001 to 2006



Note: Refer to Appendix D for definitions of airspace class

Contributing factors

Table 3 outlines the contributing factors that could be identified for the violations of controlled airspace occurrences. In 94 per cent of occurrences, actions by the flight crew contributed to the VCA. The most common crew action was failure to request an airways clearance from air traffic control (ATC). Factors such as distraction, workload or area familiarisation may have contributed to the failures to request a clearance, but the reason was generally not recorded in the notification reports. The second most common crew action was a failure to comply with ATC instructions. Again, the underlying reason for the failure to comply could generally not be identified from the notification reports. Those two categories; no clearance and failure to comply, accounted for the vast majority of VCA events (85 per cent collectively).

Of the 122 VCA occurrences, only three were ATC related where ATC actions contributed to the VCA. For example, a trainee controller, before being corrected by a supervisor, directed a pilot to fly though an area active for gliding activities. In another occurrence, a controller inadvertently activated a different flight plan associated with the aircraft callsign resulting in the aircraft entering controlled airspace without the appropriate coordination and clearance. In the third occurrence, an aircraft entered a military restricted area with a clearance that was based on incorrect information held by ATC.

Table 3: VCA contributing factors, 2001 to 2006

Contributing factor		Frequency	Per cent
Crew related	No clearance requested	87	71.3
	Failure to comply with ATC instruction	17	13.9
	Diversion due to weather	5	4.1
	Circuit deviation	3	2.5
	Track deviation	1	0.8
	Misread chart	1	0.8
	Chart interpretability	1	0.8
ATC related		3	2.5
Communication equipment failure		2	1.6
ATC and crew		1	0.8
Chart error		1	0.8
Total		122	100

Summary

In summary, VCA events have remained stable over the period studied, generally occurring when aircraft entered CTA, primarily Class C airspace, and were commonly attributed to crew actions rather than ATC procedures. The rate of VCA events has remained low at around five events per 100,000 flying hours and very few of those occurrences have resulted in aircraft coming into close proximity with each other.

Some examples of the circumstances that resulted in a VCA are presented below.

VCA occurrences

Occurrence number 200101277

While en route, the Piper Chieftain aircraft was observed on radar to have entered CTA without a clearance. The pilot was questioned about the aircraft's track as it was different to the flight planned track. The pilot was reportedly aware of the difference in tracks, but had omitted to amend the flight details.

Occurrence number 200501686

The pilot of a Cessna Conquest requested climb to flight level (FL) 200 (20,000 ft). The base of CTA was FL180 and the pilot was instructed to remain OCTA. A short time later, the pilot reported maintaining FL200. An onwards clearance was subsequently issued.

Occurrence number 200602735

While conducting a RUNWAY 11C BANKSTOWN ONE departure, which required a turn onto assigned heading after passing 500 ft, the Cessna Citation was observed on radar to maintain runway heading until passing 700 ft. The Citation subsequently penetrated the Sydney CTR without a clearance and conflicted with the Boeing 737 on final for runway 07 at Sydney. Separation reduced to 2.4 NM laterally and 900 ft vertically. Radar separation standards were infringed.

3.3.4 Breakdown of separation (BOS) and airprox

A breakdown of separation is defined as a failure to maintain a recognised separation standard between aircraft that are being provided with an ATC separation service. An 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. Breakdown of separation occurrences and airproxes can occur between two or more aircraft, an aircraft and a parachutist, or an aircraft and a vehicle on the runway. The following results refer to all three combinations.[13]

Breakdown of separation and airprox occurrences between 2001 and 2006 involving charter operations are presented in Table 4. There were approximately 15 occurrences per year between 2001 and 2004. That number increased by 77 per cent to 23 occurrences in 2005 and increased again in 2006 to 27 occurrences. Breakdowns of separation were more commonly reported and accounted for 72 per cent of occurrences. The way in which BOS and airprox events are defined lends itself to the more common reporting of BOSs compared to airproxes. The definition of an airprox requires a judgement to be made, usually by the crew, about what constitutes a threat to safety whereas most BOS are able to be identified by secondary means such radar or air traffic control. Of these 108 BOS/airprox occurrences, six per cent were sufficiently serious to warrant investigation by the Australian Transport Safety Bureau (ATSB).

Table 4: BOS and airproxes, 2001 to 2006

Year	BOS	Airprox	Total
2001	11	4	15
2002	14	2	16
2003	10	4	14
2004	7	6	13
2005	15	8	23
2006	21	6	27
Total	78	30	108

Note: The above table provides data on both Australian and foreign registered aircraft.

The combined rate of BOS and airprox occurrences for VH-registered charter aircraft increased from 3.3 per 100,000 flying hours in 2001 to 5.3 in 2006 (Figure 13). However, this change in the rate between 2001 and 2006 was not statistically significant.[14]

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[13] These figures exclude breakdown of wake turbulence separation standards.

[14] Statistical significance based on a generalised linear regression assuming a negative binomial distribution ($\chi^2 = 0.04$, $p = 0.84$).

Figure 13: Number and rate (per 100,000 hours flown) of combined BOS and airprox occurrences involving VH-registered aircraft, 2001 to 2006

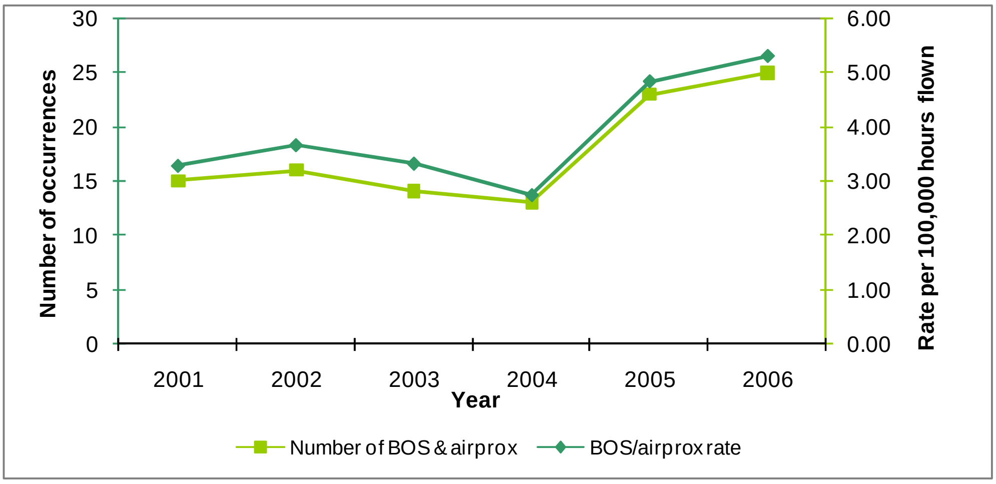
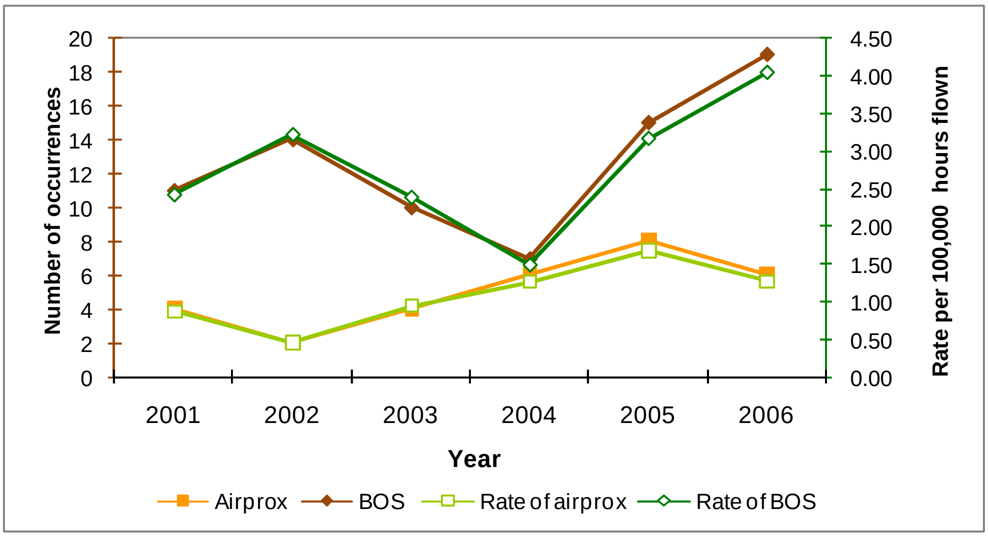


Figure 14 presents the rate for BOS and airprox occurrences separately. The rate of BOS rose from 2.4 in 2001 to 4 per 100,000 hours flown in 2006. The airprox rate rose from 0.9 in 2001 to 1.3 in 2006. The observed changes in the rate of BOS and airproxes, comparing 2001 with 2006, were not statistically significant.[15]

Figure 14 suggests that the relationship between BOS and airprox occurrences, for charter operations, are not closely aligned, with the number of BOS and airprox occurrences increasing and decreasing at different times.

It would be desirable to have a better indicator of the risk of BOS occurrences than the rate per hours flown. A rate per aircraft takeoff and landing would be better because aircraft are generally in closer proximity to each other during these activities. Unfortunately movement data for charter operations is not collected and only a rate per hours flown could be calculated.

Figure 14: Number and rate (per 100,000 hours flown) of BOS and airprox occurrences involving VH-registered aircraft, 2001 to 2006



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[15] Statistical significance based on Poisson regression of BOS occurrences ($\chi^2 = 1.85$, $p = 0.17$) and airprox occurrences ($\chi^2 = 0.34$, $p = 0.56$).

Location, airspace type and aircraft operation type

To further explore why the number of BOS occurrences increased in the later years, several characteristics of BOS occurrences were studied. Those characteristics included the state/territory, type and class of airspace where events occurred, and aircraft operation type at the time of the occurrence. Figure 15 presents information on the State/Territory where BOS occurrences occurred. The data shows that 2004 was an unusual year with no occurrences reported in New South Wales, the Northern Territory or South Australia. In 2005 and 2006, there was an increase in occurrences in the Northern Territory, Western Australia and South Australia. The increase in BOS occurrences in later years may reflect a combination of increased flying activity in states associated with the resources boom and the unusual distribution of occurrences in 2004. With such small numbers, it is important to note that graphical displays can make any changes appear more dramatic.

Figure 15: BOS by State or Territory of occurrence, 2001 to 2006

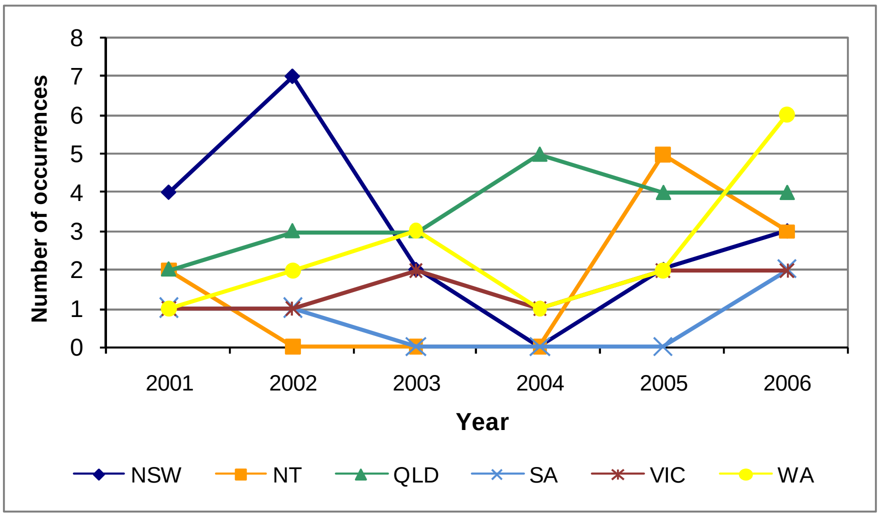

Table 5 lists the type of airspace where BOS and airprox events occurred. The majority of BOS events occurred in control areas (CTA). Airprox occurrences primarily occurred in mandatory broadcast zones (MBZ) or areas requiring the equivalent common traffic advisory frequency (radio) (CTAF(R)) procedure.[16] The CTAF category included two occurrences in CTAF(R) and six occurrences in CTAF areas. Twenty seven of the 30 airprox events occurred in Class G airspace.

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[16] On 24 November 2005, the MBZ procedure was replaced by the CTAF(R) procedure.

Table 5: BOS and airprox by type of airspace, 2001 to 2006

Airspace type		Airprox	BOS	Total
Controlled	CTR	2	19	21
	CTA	1	57	58
	OCA	0	1	1
	PRD Area	0	1	1
Uncontrolled	CTAF	6	0	6
	MBZ/CTAF(R)	14	0	14
	OCTA	7	0	7
Total		30	78	108

Note: A list of definitions for airspace type is provided at Appendix D.

Table 6 lists the class of airspace where BOS events occurred. The majority (72 per cent) of BOS events occurred in Class C airspace (controlled airspace around major city airports). The trend across 2001 to 2006 for Class C closely resembled the total BOS trend shown in Figure 14 above. The number of BOS occurrences in the other airspace classes was too low for trend analysis.

Table 6: BOS occurrences by airspace class, 2001 to 2006

Year	Class A	Class C	Class D	Class E	Unknown	Total
2001	1	9	1	0	0	11
2002	0	13	0	1	0	14
2003	1	8	1	0	0	10
2004	2	3	0	2	0	7
2005	1	12	0	2	0	15
2006	4	11	0	5	1	21
Total	9	56	2	10	1	78

The operation type of the second (or third) aircraft involved in BOS/airprox occurrences was also analysed. Unfortunately, the operation type could not be identified for the vast majority of the second aircraft.

Contributing factors and recovery measures

Table 7 identifies the personnel and factors that contributed to the 108 BOS/airprox occurrences involving charter aircraft.

Table 7: Contributing factors for BOS and airprox occurrences, 2001 to 2006

Contributory factors	Frequency	Per cent
Other (non-charter) aircraft flight crew	36	33.3
ATC procedures	35	32.4
Charter flight crew related		
Failure to comply with ATC instruction		
Instruction	9	8.3
Altitude bust	8	7.4
Violation of controlled airspace	6	5.6
Communication procedures	2	1.9
Self separation procedures	2	1.9
Transponder operation	2	1.9
No clearance requested	1	0.9
Charter crew sub-total	*30*	*27.8*
Charter flight crew and other aircraft flight crew		
Self separation procedures	2	1.9
Failure to comply with ATC instruction	1	0.9
Communication equipment failure	2	1.9
ATC procedures and charter flight crew	1	0.9
ATC procedures and other flight aircraft crew	1	0.9
Total	108	100

The contributing factors generally differed depending on who the action was attributed to. Thirty two per cent of occurrences were a result of ATC procedures or actions with the remainder attributed to flight crew actions or procedures. Some examples of the ATC procedures category include:

- a breakdown of coordination between approach and tower controllers. For example, instructions provided to the pilot from the approach controller resulted in penetration of tower airspace;
- an error in judgement when sequencing aircraft resulting in less than the required horizontal spacing, a loss of separation assurance, or a BOS. For example, landing aircraft crossing the runway threshold prior to a departing aircraft becoming airborne;
- a misunderstanding of the disposition of the aircraft or a miscalculation of aircraft performance by ATC. For example, two aircraft were assigned FL330. The second aircraft, which was faster than the leading aircraft, was reassigned FL310, however it then reached FL310 before the first aircraft reached FL330 resulting in a BOS;

- the incorrect application of a standard, such as:
  - assigning responsibility for visual separation to the pilot above FL125 (when neither aircraft was descending or on different tracks);
  - a distance standard incorrectly applied to establish definite passing of two aircraft;
  - the application of reduced vertical separation minima when the aircraft was not appropriately equipped; and
- miscommunication between ATC and pilot leading to the pilot misunderstanding the instruction, often associated with non-standard phraseology or call sign confusion.

The prevalence of BOS occurrences has been the subject of extensive review by Airservices Australia as part of their ongoing quality management processes (Airservices Australia, 2003b, 2005). As part of their development of a best-practice service, Airservices continuously reviews occurrences to identify any trends in performance.

The flight crew played a role in the outcome in 69 of the 108 occurrences. This could be due to actions by flight crew alone, in conjunction with ATC, or in conjunction with the crew of another aircraft. Approximately half of those 69 occurrences were attributed to the actions of the flight crew from a charter aircraft.

The most common contributing factor for charter flight crews was non-compliance with the ATC instructions. This was followed by altitude busts, where an aircraft was flown above or below the assigned altitude, and violation of controlled airspace occurrences.

The underlying reasons for the failure to comply could generally not be identified from the data. However, unexpected aircraft performance, workload or task distraction, or insufficient planning, were potential reasons identified behind the failures to comply from the following occurrence summaries.

- A pilot was instructed by ATC to maintain 5,000 ft due to crossing traffic at 6,000 ft. She reported that she trimmed the aircraft to maintain 5,000 ft, but that the aircraft inadvertently climbed to 5,140 ft.
- A pilot climbed through an assigned level while he was providing guidance to the copilot on the use of an aircraft system.
- A pilot failed to comply with ATC report requests and approach clearance, and as a consequence, crossed the track of another aircraft. The pilot was directed to approach from the north and subsequently tracked to the south. It is believed the pilot was not carrying the necessary chart, leading the pilot to fly the approach from memory.

The contributing factors data for the more common BOS occurrences were compared across each year. The analysis indicated that the apparent growth in BOS events in 2005 and 2006 included an increase in both ATC-attributed and crew-attributed BOS occurrences.

In 94 per cent of BOS occurrences, ATC identified the loss of separation and implemented corrective action. The crew detected the loss of separation in 12 per cent of occurrences. On a number of occasions, both aircrew and ATC detected the loss of separation. The most common response to the loss of separation was the issuing of new ATC instructions.

In 93 per cent of airproxes, not surprisingly, the crew detected the loss of separation, usually by sighting the other aircraft. The traffic alert and collision avoidance system (TCAS) was the primary detection method in only one of the airprox occurrences.

It should be noted that the final responsibility for maintaining separation between aircraft always falls to the pilot in command, irrespective of the services provided by ATC.

Summary

A summary of the findings of this section are presented below:

- The combined rate of BOS and airprox occurrences for VH-registered aircraft changed from 3.3 per 100,000 flying hours in 2001 to 5.3 in 2006. However, this change in the rate was not statistically significant.
- The observed changes in the separate BOS and airprox rates, comparing 2001 with 2006, were also not statistically significant. The rate of BOS was 2.4 per 100,000 hours flown in 2001 and 4.0 in 2006. The airprox rate was 0.9 per 100,000 hours flown in 2001 and 1.3 in 2006.
- The locations where BOS occurrences increased were resource rich states, Western Australia, South Australia and the Northern Territory, suggesting a possible link between increased flying activity and the resources boom.
- The majority of BOS occurrences occurred in CTA, primarily Class C airspace while airproxes predominantly occurred in MBZ/CTAF(R), Class G airspace.
- Thirty two per cent of BOS/airprox occurrences were attributed to ATC procedures, 28 per cent to the charter crew, 33 per cent to the other aircraft crew and the remainder attributed to a combination of the above categories.

Some examples of BOS and airprox occurrences are included below.

Breakdown of separation or airprox occurrences

Occurrence number 200204123

During coordination, an incorrect assigned altitude was entered by air traffic control into the air traffic control computer system resulting in an infringement of separation standards.

Occurrence number 200601680

While departing from active runway 08, a Sikorsky S76 helicopter came into close proximity to a light aircraft landing on runway 26. Both crews had maintained radio contact, however, the light aircraft pilot did not provide complete and appropriate calls about the landing runway. The helicopter pilot had repeatedly advised the intention to depart from runway 08. Both pilots took avoidance action.

Occurrence number 200603111

At 0805 Eastern Standard Time, a Boeing Company 737-7Q8 aircraft (737) passed within 400 ft vertically of an Aero Commander 680-FL (Aero Commander) aircraft. At that time there was less than the minimum 3 NM radar separation standard or the 1,000 ft vertical separation standard between the two aircraft.

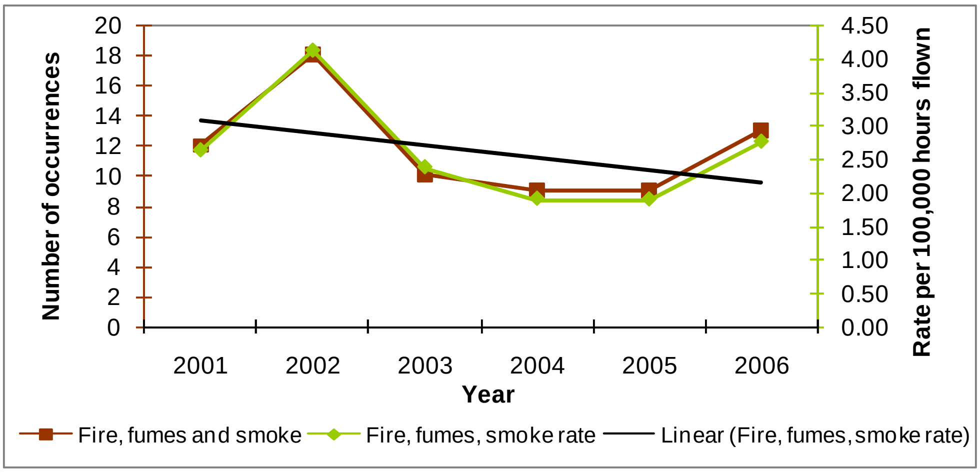
The 737 departed Melbourne Airport tracking to the north and then to the north-east of Melbourne on a runway 27 DOSEL 3 standard instrument departure (SID). The Aero Commander, transporting freight, became airborne off runway 35 at Essendon. The pilot of the Aero Commander was instructed to track overhead Melbourne Airport and climb to 3,000 ft. From overhead Melbourne Airport, the pilot was instructed to fly a heading of 310 degrees magnetic.

The pilot of the Aero Commander advised the departures controller that he had the 737 in sight. However, there was a breakdown of separation standards because the departures controller did not comply with the requirements of the Manual of Air Traffic Services (MATS) when he assigned separation responsibility to the pilot of the Aero Commander.

3.3.5 Fire, smoke, explosion or fumes

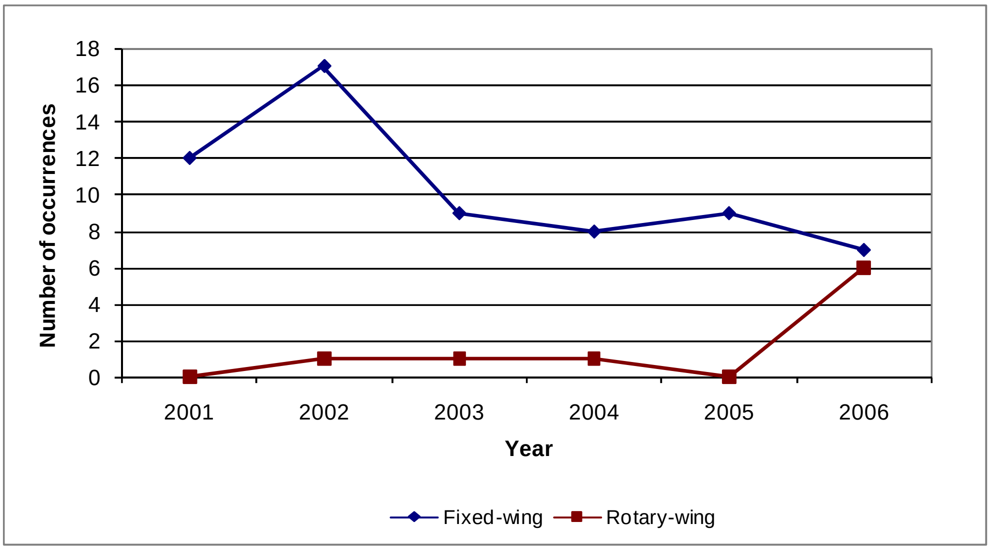
There were 71 occurrences involving fire, smoke, or fumes in charter operations between 2001 and 2006. The number of occurrences peaked at 18 in 2002 (see Figure 16). The rate of occurrences per 100,000 flying hours appeared to trend downward, primarily due to the low number of occurrences recorded in 2004 and 2005. However, the trend in the rate of fire, smoke or fumes occurrences was not statistically significant.[17] There were no occurrences involving an explosion during the time period.

Figure 16: Number and rate (per 100,000 hours flown) of reported fire, smoke or fumes occurrences, 2001 to 2006



The observed rise in occurrences between 2001 and 2002 reflected an increase in occurrences in fixed-wing aircraft while the rise between 2005 and 2006 reflected the jump in occurrences in rotary-wing aircraft (see Figure 17).

Figure 17: Fire, smoke or fumes occurrences by aircraft type, 2001 to 2006



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[17] Poisson regression ($\chi^2 = 0.01$, p = 0.91).

Table 8 indicates that over half the occurrences involved smoke (of which 14 per cent co-occurred with fumes), while only 13 occurrences involved fire.

Table 8: Reported fire, smoke, or fumes occurrences by category, 2001 to 2006

Category	Frequency	Per cent
Smoke	30	42.3
Fumes	18	25.4
Fire	13	18.3
Fumes and smoke	10	14.1
Total	71	100

Table 9 summarises the 13 fire-related occurrences, including the location where the fire occurred, the aircraft type, the phase of flight at the time the fire started and where possible, and the source of the fire.

Table 9: Location of fire, contributory factor and phase of flight when fire occurred, 2001 to 2006

Occurrence number	Aircraft type	Location of fire	Contributory factor	Phase of flight
200102471	Cessna 402C	Engine - exhaust system	Excess fuel pooling in blocked exhaust system	Standing
200102546	De Havilland DHC-8-102	Engine - turbine case	Burst oil line	In-flight
200102710	Embraer EMB-110P1	Engine	Cracked fuel return line	In-flight
200104640	Cessna U206G	Fuel pump line	Cracked fuel line	In-flight
200200151	Piper PA-32-300	Brakes	Over heated brakes due to parking brake engaged during take off run	Takeoff
200202068	Cessna 310R	Engine - exhaust system	Possible over priming	Standing
200204261	Fairchild SA227-AT	Engine	Fuel flooding	Standing
200205228	Cessna 404	Landing gear	Over heated brakes due to valve failing to release	Standing
200205442	Piper PA-32-260	Engine – cowling	Unknown	Standing
200303292	Piper PA-31-350	Engine	Unknown	Standing
200303701	Piper PA-31-350	Engine	Catastrophic engine failure	In-flight
200304623	Swearingen SA226-TC	Landing gear	Ruptured hydraulic line	Standing
200500170	Swearingen SA226-TC	Landing gear	Incorrect brake part fitted	Standing

Eight of the fires occurred in the engine and four involved the landing gear (including the brakes). Four of the 13 fires occurred during flight. It was more common for the fire to occur when the aircraft was standing either when starting the engine or following a landing.

Smoke and fumes, or a combination of the two, were considerably more common than actual fires. The most common source of smoke and fumes was the heating of electrical components, often as a result of shorting or arcing. The failure of aircraft components along with the heating of leaking fuel, oil or hydraulic fluid also resulted in the detection of smoke and/or fumes. Examples of failed components included: the blower fan; air cycle machine; air conditioner motor; starter generator motor; directional gyro unit; transponder; emergency pressurisation valve; piston; direct current (DC) generator; and the landing gear motor. Less common reasons for the detection of smoke and/or fumes included the leaking of a dangerous goods container, the inadvertent directing of air from the engine to the cabin, and the use of an overly rich fuel mixture when starting the aircraft.

Several examples are presented below, ranging from the more serious in-flight fire to the detection of smoke or fumes in the cabin.

Fire, smoke, fumes occurrences

Fire (Occurrence number 200102546)

As the de Havilland Dash 8 aircraft, with 32 people on board, was passing through FL140 in the climb, the crew heard a loud thump from the area of the left engine. This was followed by a fire bell for the left engine and the fire handle indicator came on. The crew completed the appropriate fire drills and the fire handle indicator light went out approximately 27 seconds later. The flight was then diverted for a safe landing at Roma.

Initial examination of the engine has found that the externally routed oil supply line to the number 6 and 7 bearing was broken. One of the supporting clips for the oil line was also found broken. The evidence indicates that the oil then sprayed onto the hot turbine section outer case and ignited. The fire damage was confined to this area. An examination of the oil line and support indicated that they failed as a result of a vibration induced fatigue fracture.

Fire (Occurrence number 200500170)

Upon parking at the bay at the completion of the flight, the pilot noticed a small fire in the right main landing gear. The aviation rescue and fire fighting service was summoned and the fire was extinguished. Engineering inspection revealed that a brake part fitted earlier was not the correct part number for this particular Metro 2 aircraft.

Fumes (Occurrence number 200602908)

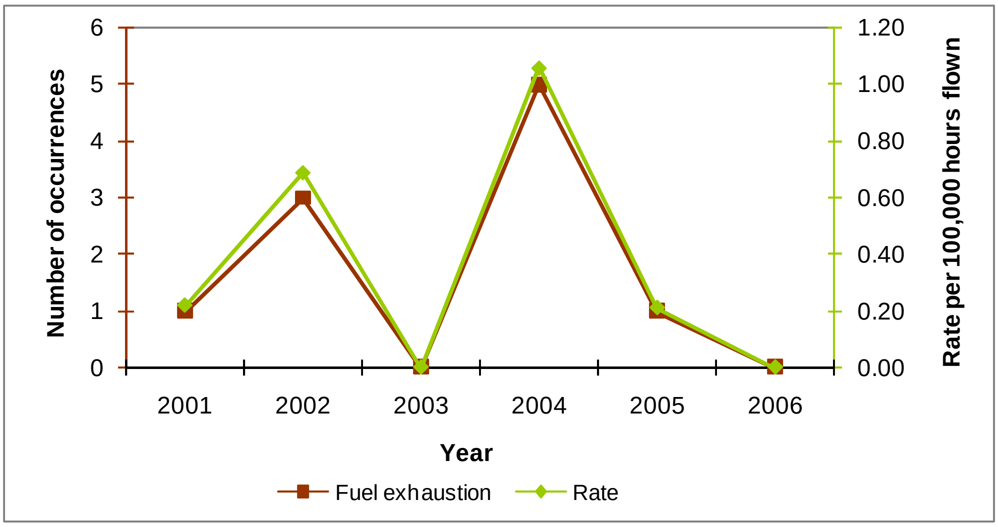
Shortly before descent into West Sale, the crew noticed a burning smell in the cabin. The appropriate emergency actions were carried out and the Aerospatiale Super Puma helicopter landed without further incident. An inspection revealed a small amount of fluid in the autopilot heater. The area was cleaned and the helicopter returned to service.

3.3.6 Fuel exhaustion

There were 10 reported occurrences of fuel exhaustion in charter operations between 2001 and 2006. The numbers ranged from one occurrence in 2001 to a peak of five occurrences in 2004. There were no reported occurrences in 2003 or 2006 (see Figure 18). The rate of occurrences for the combined time period was 0.4 occurrences per 100,000 hours flown.

Fixed-wing aircraft were involved in eight of those occurrences while rotary-wing aircraft were involved in the remaining two occurrences. None of those occurrences resulted in injuries to the aircraft occupants.

Figure 18: Fuel exhaustion occurrences, 2001 to 2006



The reasons identified for the exhaustion of fuel in those occurrences included: a faulty fuel gauge; inadequate pre-flight fuel quantity assessment; inaccurate fuel calculations; and fuel leaks due to a fuel cap being left off and a fuel system component failure.

Several examples from this category of IRM are presented below.

Fuel Exhaustion occurrences

Occurrence number 200200007

During cruise flight, with 11 people on board, both engines of the Nomad aircraft failed. The pilot then conducted a successful forced landing on a beach. After the landing, company personnel noted that the left fuel gauges indicated 120 lbs and the right fuel gauges indicated 160 lbs.

Before his initial departure, the pilot had noted the fuel gauge indications and asked the refueller to add 200 litres of fuel to the aircraft. The pilot did not mention to the refueller that he intended to depart with full fuel tanks. After the refuelling was completed, the pilot did not visually check the contents of the fuel tanks. The refueller later stated that neither fuel tank was full after refuelling.

The company operations manual required the pilot in command, before flight, to verify using fuel gauges and visually that the total fuel on board was sufficient for the flight. The pilot stated that he had never visually checked fuel tank contents in the Nomad or Caravan. Other company pilots said it was rare for company pilots to visually check the contents of aircraft fuel tanks.

The pilot had accumulated a total of 70 hours in the Nomad. The majority of his recent flying was in Cessna Caravan aircraft, in which he had accumulated 1,500 hours.

Inspections of the fuel tanks identified that all four fuel quantity transmitters were contaminated by microbiological material. The level of microbiological material in the transmitters was sufficient to affect their accuracy. The aircraft manufacturer recommended that fuel tanks and fuel quantity transmitter units be cleaned every 1,800 hours time in service. On this aircraft, the transmitter units had been cleaned less than 1,000 hours prior to the occurrence.

The evidence indicated that the aircraft's engines failed due to fuel exhaustion. The pilot's method of establishing fuel on board was not robust, with no provision for the possibility of errors in the fuel quantity indicating system. It is possible that the perceived reliability and accuracy of the Caravan fuel quantity indicating system influenced the extent of the pilot's reliance on fuel gauge indications.

Occurrence number 200201471

The pilot of an Aero Commander 500S was cleared to descend to 4,500 ft en route from Port Pirie to Adelaide but ATC noticed that the aircraft had descended to 4,200 ft. Air traffic control contacted the pilot who reported that he was having engine problems and was unable to maintain altitude. The pilot advised that he was going to attempt a landing at Lower Light, an airstrip approximately 30 NM north-west of Adelaide. An alert phase was declared. The pilot later advised that he could not make Lower Light and would attempt to land in a paddock. A distress phase was declared and a following Piper PA31-350 (Chieftain) was vectored to the position of the last radar contact with the Aero Commander. The pilot of the Chieftain later reported that he had located the Aero Commander and had made radio contact with the pilot. The Aero Commander had landed in a paddock. The pilot, who was the only occupant, was uninjured and the aircraft did not appear to be damaged.

An inspection found that the engines had stopped due to fuel exhaustion. There had been some confusion by the pilot about fuel uptake at Adelaide following the previous night's operations and he had not physically checked the actual fuel on board.

Occurrence number 200403785

Shortly after the Bell 47G helicopter had departed Long Island, Queensland, with three people on board, at a point about 0.5 NM east of South Head and at 500 ft above the sea, the engine lost power. The pilot placed the float-equipped helicopter into autorotation, transmitted a MAYDAY call then landed the helicopter safely on the sea surface.

After landing, the pilot was able to restart the engine but shut it down again due to lack of tail rotor control due to the absence of part of the tail rotor shaft. The helicopter was then towed by a boat to a beach at Long Island.

At the beginning of the days' flying, the helicopter was fuelled to 165 litres and the pilot carried out a check for water in the fuel. The pilot then carried out six scenic flights over two hours before shutting down and confirming that the helicopter had between 50 and 60 litres of fuel remaining. The pilot flew the aircraft for another half hour before the engine lost power.

After the helicopter had been returned to the beach at Long Island, the operator's chief pilot added 10 litres of fuel to each of the two tanks and attempted to start the engine to test for a blockage or other fuel system problem. The chief pilot then noticed fuel dripping from the fuel drain at a rate of 120 drops per minute from the unit's tap and also fuel oozing out from the side of the unit.

3.3.7 Crew injury or incapacitation

There were three reported incidents of crew injury/incapacitation in the 6 years studied (see Table 10). All three occurrences involved incapacitation. On two occasions, the pilot affected was operating as a single-pilot operation. The third occasion involved the copilot of a multi-crew flight.

Table 10: Crew injury or incapacitation, 2001 to 2006

Year	Frequency
2001	0
2002	0
2003	1
2004	0
2005	2
2006	0
Total	3

Below are summaries of the three occurrences where crew were incapacitated.

Crew Incapacitation occurrences

Occurrence number 200303631

While en route, the copilot became incapacitated. The pilot in command diverted the Beech B1900 aircraft to Carnarvon where medical assistance was provided on arrival.

Occurrence number 200504621

Prior to departure, the Australian Quarantine and Inspection Service (AQIS) officer sprayed the baggage area of the Britten Norman Islander aircraft with a chemical substance. While en route, the pilot became incapacitated from the fumes and received medical treatment on arrival at Horn Island, Queensland.

Occurrence number 200506083

After starting the engine of the Eurocopter Squirrel, the pilot became incapacitated. The passengers shut the engine down without damage or injury.

3.3.8 Other immediately reportable matters

There was one incident of an uncontained engine failure while conducting charter operations during the 6-year period studied involving a Cessna 206 in May 2004. The aircraft departed from Cairns with a destination of Margaret Bay, Queensland. While en route, the engine began to run rough before the number four cylinder ejected from the engine through the left engine cowl. The pilot declared a PAN and diverted to an alternative aerodrome for a safe landing.

3.4 Source of notifications

To sketch out a picture of who is reporting aviation occurrences, the source of the notification to the ATSB was analysed. Notifications of IRM occurrences were received from air traffic control, crew and operators, airport ground staff, police, Australian Search and Rescue (AUSSAR), military and the public. Airservices Australia reported, by far, the most occurrences including occurrences in every category of IRM reviewed and not just airspace-related IRMs. In some instances, the notification from Airservices Australia was the only occurrence report received.

It is difficult to determine whether all IRMs are being reported. The general increase in the number of charter incidents reported supported by the introduction of the TSI Act and TSI Regulations in mid 2003, along with the consistent reporting of IRMs over the 6-year period studied, suggests that there has been an increase in the reporting of routine reportable matters. The TSI Regulations better specified a comprehensive range of incidents that are required to be reported to the ATSB.

Flight crews and operators could help expand the information available, to the benefit of the entire industry, by providing the notification reports that not only describe what happened but also why they believed it happened.

4 CONCLUSIONS

The charter industry appears to be in a period of transition with some sectors of the industry expanding while others have contracted. Overall activity, measured as flying hours, initially declined over the study period followed by higher activity from 2004 to 2006. However, while the number of charter hours flown increased in the later years studied, the number of hours flown in 2006, the latest year reviewed, was not as high as the historical peak in charter hours observed in 1999. The number of charter operators decreased in 2005 and 2006 so fewer operators have conducted more of the hours flown in those years. The type of aircraft flying charter operations has also changed with more hours flown in multi-engine aircraft.

This growth in flying hours in the later years may be associated with the resources boom and growth in fly-in fly-out services to mining areas. Without information on the type of activities charter operators were performing, this cannot be substantiated.

Immediately reportable matters (IRMs) for charter operators across the 2001 to 2006 period remained stable for the total reports and for each of the selected categories of IRMs with the exception of accidents.

The rate of accidents involving charter aircraft dropped significantly between 2001 and 2006, while at the same time the rate of reported incidents increased. The most common type of accident experienced in charter operations was wheels-up landing either due to mechanical problems with the landing gear or due to crew operation of the landing gear. The more severe occurrence types involved collisions, loss of control of the aircraft, and loss of power from the engine.

The rate of violation of controlled airspace (VCA) occurrences remained stable, with an overall rate of approximately four occurrences per 100,000 flying hours. The number of breakdown of separation (BOS) occurrences changed from two in 2001 to four BOS events per 100,000 flying hours in 2006. That change was not statistically significant.

The fire, smoke, fumes category remained stable with no change in the rate of occurrences between 2001 and 2006. Other IRM categories, such as crew injury/incapacitation, uncontained engine failures, and fuel exhaustion, while having the potential for serious consequences, were rare.

This review provided encouraging data on the charter accident rate, emphasised the stability of the rate of airspace related occurrences and fire, smoke or fumes occurrences, and the rarity of uncontained engine failures and crew incapacitation in charter operations. While the rate of BOS occurrences remained stable, those occurrences continue to be closely monitored by all aviation agencies with the aim of prevention and continuous improvement in both flying and air traffic control.

Regulatory change appears to be part of the future for passenger charter operations with proposed changes aimed at harmonising the crew licensing requirements between RPT and charter. Ongoing reviews of immediately reportable matters for all air transport operations could help inform both regulatory change and the safety management of charter operators.

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6 APPENDICES

6.1 Appendix A: Sources and submissions

6.1.1 Sources of information

The primary sources of information used during this investigation were:

- the aviation accident and incident databases maintained by the Australian Transport Safety Bureau (ATSB); and
- Australian flying-hours data provided by the Bureau of Infrastructure, Transport and Regional Economics from responses to the annual *General Aviation Activity Survey*.

A more detailed description of the data sources is provided in the *Methodology* (Chapter 2) and *References* (Chapter 9).

6.1.2 Submissions

A draft of this report was provided to the Civil Aviation Safety Authority (CASA); the Department of Infrastructure, Transport, Regional Development and Local Government (the Aviation and Airports Business Division and Bureau of Infrastructure, Transport and Regional Economics); Airservices Australia; and the Regional Aviation Association of Australia.

Submissions were received from CASA and the Bureau of Infrastructure, Transport and Regional Economics. The submissions were reviewed and where considered appropriate, the text of the report was amended accordingly.

6.2 Appendix B: Reporting of occurrences

6.2.1 Reporting requirements for all aircraft operations since 1 July 2003[18]

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.

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[18] Transport Safety Investigation Regulations 2003 (Reg 2.3)

6.2.2 Reporting requirements for all air transport operations since 1 July 2003[19]

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;

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[19] Transport Safety Investigation Regulations 2003 (Reg 2.3 and 2.4)

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.

6.3 Appendix C: Occurrence type definitions

The ATSB Occurrence Type taxonomy is a three-level hierarchy. The Level 1 Occurrence Type groupings are called:

- Operational
- Mechanical
- Airspace
- Aerodromes and Ground Facilities

Each of the Level 1 Occurrence Type groupings are sub-divided into a number of related Level 2 groupings. Listed below are a set of definitions used in Section 3.3.2, presented under the appropriate Level 1 category. Only those occurrence type definitions referred to in the report are presented.

Operational

Incorrect configuration	Occurrences where the aircraft systems are incorrectly set (by commission or omission) for the current and/or intended state of aircraft operations.
Loss of control	Occurrences where a pilot is unable to maintain positive control of an aircraft, either during flight or on the ground.
Mid-air collision	Occurrences where there is a collision between two or more aircraft in the air.
Collision with terrain	Occurrences involving a collision between an airborne aircraft and the ground or water, where the flight crew were aware of the terrain prior to the collision.
Controlled flight into terrain	Occurrences where a serviceable aircraft, under the flightcrew's control, is inadvertently flown into terrain, obstacles, or water without either sufficient or timely awareness by the flight crew to prevent the event.
Collision on ground	Occurrences where an aircraft has a collision with another object whilst it is operating on the ground or water.
Fuel related-exhaustion	Occurrences where the aircraft has become completely devoid of useable fuel.
Fuel related-starvation	Occurrences where the fuel supply to the engine(s) is interrupted, although there is usable fuel on board the aircraft.
Fuel related-contamination	Occurrences where there is the presence of a substance in fuel, which should not normally be present.

Significant even -fire	Occurrences where a fire has been confirmed, or the fire suppression system has activated.
Significant event-forced landing	Occurrences where an aircraft attempts a landing in situations where continued flight is not possible.
Wheels-up landing	Occurrences where an aircraft with retractable landing gear lands without the landing gear fully extended and locked before contact with the ground or runway.
Significant event-hard landing	Occurrences where a landing is reported as heavy or hard, where aircraft damage is indicative of a hard landing.
Significant event-other	Significant event occurrences not specifically covered elsewhere. Significant event - other occurrences include, but are not limited to, events such as a: precautionary in-flight engine shutdown; emergency descent; significant exceedence of G limits; blocked pitot tube or static vent; or nose-over or nose-down.
Ground operations-foreign object damage/debris (FOD)	Occurrences where it is reported that loose objects on the ground have caused, or have the potential to cause, damage to an aircraft.
Ground operations-excursion	Occurrences where an aircraft on the ground departs from a runway or taxiway.
Ground operations-other	Ground operations occurrences not specifically covered elsewhere. Ground operations-other occurrences can include: ground vehicles failing to give way to aircraft on taxiways; fuel spills during refuelling, including venting spills; or landing short of a runway.
Birdstrike	Occurrences where there is a collision between an aircraft and a bird.
Animal strike	Occurrences where there is a collision between an aircraft and an animal.

Mechanical

The Airframe group of Occurrence Types broadly covers occurrences in which there has been significant damage to, or failure of, a structural component of the aircraft.

Airframe-landing gear	Occurrences where aircraft landing gear, brakes (or their component parts) or tyres have exhibited damage or have failed. Landing gear occurrences include: landing gear collapse due to mechanical malfunction; the use of emergency gear extension; tyre deflation; overheated or smoking brakes; faults with float type undercarriages; or faults with emergency flotation devices in helicopters.

Airframe-rotors/tail rotor	Occurrences where the rotor or tail rotor of an aircraft has exhibited damage or has failed.
Powerplant/propulsion-Power loss/engine failure	Occurrences involving the failure of an engine in flight or on the ground. Total power loss/engine failure includes: reports of total power loss of an engine; engine failure in multi engine aircraft; or transient total power loss.
Powerplant/propulsion-partial power loss	Occurrences involving a reduction in power that adversely affects the performance of the aircraft.
Systems-fuel	Occurrences involving partial or complete loss of normal functioning of an aircraft fuel system. This occurrence type covers faults in the systems for storing and supplying fuel to the engines and auxiliary power units. It includes faults related to fuel tanks, supply lines, pumps, valves, restrictors, or fuel jettison equipment.
Systems-hydraulic system	Occurrences involving partial or complete loss of normal functioning of an aircraft hydraulic system. This occurrence type covers faults in the hydraulic systems, flight controls, autopilot, landing gear, brakes, or steering. It includes faults related to hydraulic reservoirs, piping, or pumps.
Aerodrome and airways facility	
Aerodrome related	The Aerodrome related type broadly covers situations where aerodrome related infrastructure is reported as absent, inadequate, or has failed.

6.4 Appendix D: Airspace definitions

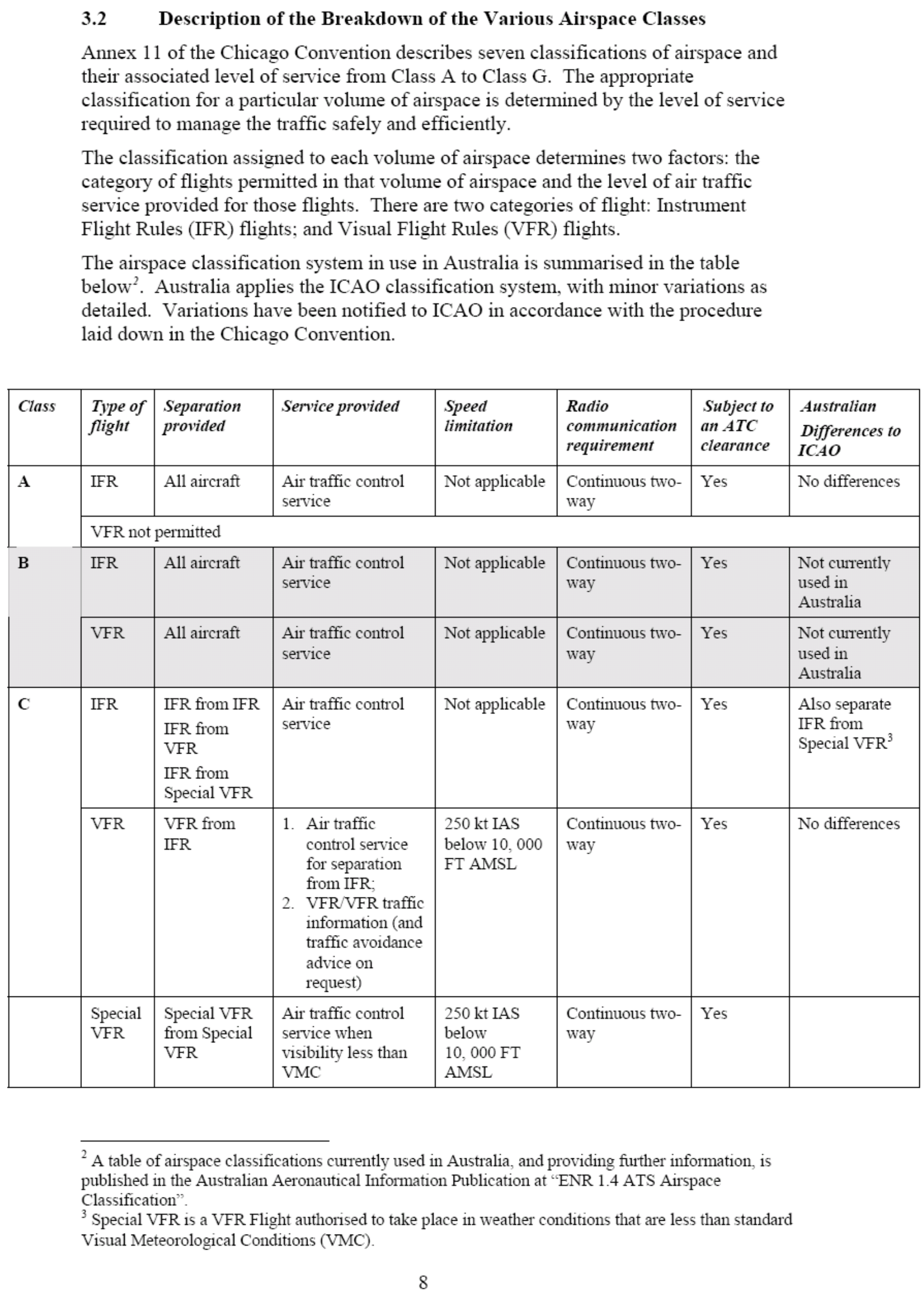
Following are a list of abbreviations and definitions used in Figure 11 and Figure 12.

Airspace types

Control zone (CTR)	CTR refers to a control zone and is defined as a controlled airspace extending upwards from the surface of the earth to a specified upper limit. It generally refers to controlled airspace around an aerodrome.
Control area (CTA)	CTA refers to a control area and is defined as controlled airspace extending upwards from a specified limit above the earth. It generally refers to controlled airspace that is not a control zone.
Common traffic advisory frequency (CTAF)	CTAF stands for common traffic advisory frequency area. It is a designated frequency and within this area pilots operating within the vicinity of a non-towered aerodromes should make positional broadcasts.
Mandatory broadcast zone (MBZ)	MBZ refers to mandatory broadcast zones and are the equivalent of CTAF (Radio) areas. Mandatory broadcast zones were replaced in November 2005 by CTAF(R) areas as part of the airspace reform program.
Oceanic areas (OCA)	OCA refers to oceanic areas.
Outside controlled airspace (OCTA)	OCTA refers to airspace outside controlled airspace.
Prohibited, restricted or danger areas (PRD)	PRD areas include prohibited, restricted and danger 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.

The above definitions were sourced from the following references: Airservices Australia, (2007), Airservices Australia, (2008) and Airservices Australia, & Department of Defence, (2008).

The below extract from *The Australian Airspace Policy Statement*[20] provides an accurate description of the classes of airspace used in Australia.



3.2 Description of the Breakdown of the Various Airspace Classes

Annex 11 of the Chicago Convention describes seven classifications of airspace and their associated level of service from Class A to Class G. The appropriate classification for a particular volume of airspace is determined by the level of service required to manage the traffic safely and efficiently.

The classification assigned to each volume of airspace determines two factors: the category of flights permitted in that volume of airspace and the level of air traffic service provided for those flights. There are two categories of flight: Instrument Flight Rules (IFR) flights; and Visual Flight Rules (VFR) flights.

The airspace classification system in use in Australia is summarised in the table below[2]. Australia applies the ICAO classification system, with minor variations as detailed. Variations have been notified to ICAO in accordance with the procedure laid down in the Chicago Convention.

Class	*Type of flight*	*Separation provided*	*Service provided*	*Speed limitation*	*Radio communication requirement*	*Subject to an ATC clearance*	*Australian Differences to ICAO*
A	IFR	All aircraft	Air traffic control service	Not applicable	Continuous two-way	Yes	No differences
	VFR not permitted						
B	IFR	All aircraft	Air traffic control service	Not applicable	Continuous two-way	Yes	Not currently used in Australia
	VFR	All aircraft	Air traffic control service	Not applicable	Continuous two-way	Yes	Not currently used in Australia
C	IFR	IFR from IFR IFR from VFR IFR from Special VFR	Air traffic control service	Not applicable	Continuous two-way	Yes	Also separate IFR from Special VFR[3]
	VFR	VFR from IFR	1. Air traffic control service for separation from IFR; 2. VFR/VFR traffic information (and traffic avoidance advice on request)	250 kt IAS below 10, 000 FT AMSL	Continuous two-way	Yes	No differences
	Special VFR	Special VFR from Special VFR	Air traffic control service when visibility less than VMC	250 kt IAS below 10, 000 FT AMSL	Continuous two-way	Yes	

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[2] A table of airspace classifications currently used in Australia, and providing further information, is published in the Australian Aeronautical Information Publication at "ENR 1.4 ATS Airspace Classification".

[3] Special VFR is a VFR Flight authorised to take place in weather conditions that are less than standard Visual Meteorological Conditions (VMC).

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[20] The Australian Airspace Policy Statement was issued under section 8 of the *Airspace Act 2007*.

Class	*Type of flight*	*Separation provided*	*Service provided*	*Speed limitation*	*Radio communication requirement*	*Subject to an ATC clearance*	*Australian Differences to ICAO*
D	IFR	IFR from IFR IFR from Special VFR	Air traffic control service, traffic information about VFR flights (and traffic avoidance advice on request)	250 kt IAS below 10, 000 FT AMSL	Continuous two-way	Yes	Also separate IFR from Special VFR
	VFR	Nil	Air traffic control service, traffic information on all other flights (and traffic avoidance advice on request)	250 kt IAS below 10 000 FT AMSL	Continuous two-way	Yes	Provide ATC service to all aircraft landing and taking off at controlled aerodromes
	Special VFR	Special VFR from Special VFR	Air traffic control service when visibility less than VMC	250 kt IAS below 10, 000 FT AMSL	Continuous two-way	Yes	Special VFR category
	All flights	Taking off and/or landing at controlled aerodromes	Air traffic control service	250 kt IAS below 10, 000 FT AMSL	Continuous two-way	Yes	Additional service
GAAP CTR	IFR	In IMC: IFR from IFR IFR from VFR	Air traffic control service	250 kt IAS	Continuous two-way	Yes	Additional service
	VFR	Nil	Air traffic control service	250 kt IAS	Continuous two-way	Yes	Additional service
E	IFR	IFR from IFR	Air traffic control service and, as far as practical, traffic information on VFR flights	250 kt IAS below 10, 000 FT AMSL	Continuous two-way	Yes	Mandatory transponder carriage and operation
	VFR	Nil	Flight Information Service	250 kt IAS below 10, 000 FT AMSL	Continuous two-way	No	Mandatory transponder carriage and operation. Also provide FIS in addition to traffic information Continuous two-way radio is required
F	IFR	IFR from IFR as far as practical	Air traffic advisory service; flight information service	250 kt IAS below 10, 000FT AMSL	Continuous two-way	No	Not currently used in Australia
	VFR	Nil	Flight information service	250 kt IAS below 10, 000FT AMSL	No	No	Not currently used in Australia

Class	*Type of flight*	*Separation provided*	*Service provided*	*Speed limitation*	*Radio communication requirement*	*Subject to an ATC clearance*	*Australian Differences to ICAO*
G	IFR	Nil	Flight information service and mandatory directed traffic information to IFR flights about other IFR flights	250 kt IAS below 10, 000FT AMSL	Continuous two-way	No	Provision of mandatory directed traffic information.
	VFR	Nil	Flight information service	250 kt IAS below 10, 000 FT AMSL	No, except VFR radio required for operations above 5,000 FT AMSL and at aerodromes where carriage and use of radio is required. Also required in reduced VMC.	No	Also require VHF radio above 5,000 FT and at CTAF(R) aerodromes and in reduced VMC.

Airspace organisation in Australia is aligned with the ICAO menu of airspace classifications and associated levels of service. The Australian Aeronautical Information Publication (AIP) provides detail on how these classifications are deployed in Australia.

Variations from the ICAO classifications in Australia are briefly explained below:

- inclusion of a Special VFR flight category;
- provision of an air traffic control separation service to aircraft landing and taking off at airports in Class D airspace;
- provision of a Flight Information Service for VFR aircraft operating in Class E airspace. Two way radio communications and mandatory transponder carriage and operation are a requirement for operations in Australian Class E airspace;
- inclusion of an additional air traffic control procedure termed General Aviation Airport Procedures (GAAP), used in Class D airspace. Air traffic control procedures at specified GAAP airports are specifically designed to handle large numbers of VFR operations;
- inclusion of more stringent radio communications requirements in Australian Class G airspace where VFR aircraft are required to have two-way radio communication capability for operations above 5,000 feet and at airports requiring a Common Traffic Advisory Frequency or CTAF(R); and
- speed limitations are not applicable to military aircraft when operating below 10,000 feet in Class C, D, E and G airspace.

In Australia Class A airspace is high–level enroute airspace and Class C generally surrounds major city airports starting at ground level and stepped up into mid-level Class C or the high level Class A airspace. However, much of Australian airspace is not controlled and thus classified as Class G.

The Australian Designated Airspace Handbook (DAH), which is published as part of the Australian AIP, contains accurate details of the actual Australian airspace architecture.

Trends in immediately reportable matters involving charter operations 2001 to 2006