



Australian Government  
Australian Transport Safety Bureau

*safe Transport*

RESEARCH REPORT  
B2003/0114

# Review of Midair Collisions Involving General Aviation Aircraft in Australia between 1961 and 2003



May 2004



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## Executive Summary

Following three midair collisions at major general aviation airports in Australia between February and July 2002, the Australian Transport Safety Bureau (ATSB) conducted a review of midair collisions in Australia between 1961 and 2003. The objectives of the review were to identify common characteristics and contributing factors, assess whether there had been a change in the midair collision rate in recent years, and to compare the characteristics and rate of midair collisions with those of other countries.

The conclusions of this review are as follows:

- There were 37 midair collisions involving general aviation aircraft in Australia during the period 1961 to 2003. Since 1968, there was approximately one midair collision per year in Australia. Most (34) of the midair collisions were accidents, and a majority (19) of these accidents resulted in fatalities.
- There were no midair collisions involving regular public transport (RPT) operations in Australia from 1961 to 2003.
- Midair collisions account for about 3 per cent of fatal accidents involving general aviation aircraft, and 0.4 of a percentage point of all accidents involving general aviation aircraft.
- Most (78 per cent) of the midair collisions that have occurred in Australia since 1961 have occurred in or near the circuit area. This reflects the higher traffic density in this area. A high proportion of the collisions (35 per cent) occurred on final approach or the base-to-final turn.
- A high proportion of the midair collisions (41 per cent) have occurred at the five major general aviation airports (Archerfield, Bankstown, Jandakot, Moorabbin, Parafield). However, the rate of collisions at these airports has decreased since the introduction of General Aviation Aerodrome Procedures in 1980.
- A range of contributing factors were involved in the midair collisions, but there were no dominant factors. Most of the collisions involved one aircraft colliding with another from behind, or both aircraft converging from a similar direction.
- In general, the characteristics and contributing factors of midair collisions in Australia appear to be similar to those observed in other countries such as the US, France and Canada.
- Australia and the US had a similar rate of midair collisions involving general aviation aircraft during the period 1981-2003. The US had a higher rate of general aviation aircraft involved in collisions per flight hour away from the circuit area, which is consistent with the US having more general aviation flying activity and a higher traffic density.



## **1. Introduction**

### **1.1 Objectives of this study**

The purpose of this review was to provide an overall indication of the risk of midair collisions to general aviation aircraft in Australia based on actual midair collision data. More specifically, the objectives of the review were to:

- review the midair collisions in Australia for the period 1961-2003;
- identify the common characteristics and contributing factors of midair collisions;
- assess whether there had been a change in the midair collision rate in Australia in recent years;
- compare the characteristics and rate of midair collisions with those of other countries.

### **1.2 Background information**

This study was initiated following the occurrence of three midair collisions in Australia during 2002:

- A non-fatal collision between a Cessna 172 and an ultralight on final approach at Jandakot airport (22 February 2002).
- A fatal collision between a Piper PA-28 and a Socata TB-9 on final approach at Bankstown airport (5 May 2002).
- A fatal collision between two Cessna 172 aircraft on final approach at Moorabbin airport (29 July 2002).

All three collisions occurred at major general aviation airports, although only one occurred during the hours when the air traffic control tower was open.

## **2. Method**

Midair collisions involving registered civil aircraft in Australia between 1969 and 2003 were identified using the ATSB aviation occurrence database.<sup>1</sup> Information on each collision was then obtained from the occurrence database and investigation reports. A review of the *Survey of Accidents to Australian Civil Aircraft*<sup>2</sup> for each year identified collision accidents between 1961 and 1968. Characteristics and contributing factors for each collision were identified by reviewing the relevant occurrence report and other database information.

The review focused on operations involving general aviation aircraft (that is, registered powered aircraft such as aeroplanes and helicopters conducting private, aerial work or charter operations). There were no midair collisions involving regular public transport (RPT) operations in Australia from 1961 to 2003.

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<sup>1</sup> The ATSB aviation occurrence database contains information on accidents and incidents only as far back as 1969.

<sup>2</sup> The *Survey of Accidents to Australian Civil Aircraft* was produced by during the years 1961-1991.

Midair collision rates in Australia were calculated using flight hours. Data on flight hours for 1961 to 2002 were obtained from Bureau of Transport and Regional Economics publications. Hours flown for 2003 were estimated based on hours for 2002. Only midair collision accidents<sup>3</sup> were included in the calculation of the collision rates to enable comparisons with the US.

Comparisons of midair collision rates were made between Australia and the US. Details on the number of midair collisions accidents involving general aviation aircraft<sup>4</sup> in the US were provided by the National Transportation Safety Board (NTSB). Basic details of these accidents were obtained by reviewing the NTSB accident database records for these accidents available through the NTSB website. Flight hours data in the US were obtained from the NTSB (news release SB-03-08, 18 March 2003 and similar previous publications). To obtain similar figures for Australia, US general aviation and 'on-demand air taxi' flight hours were summed, and flight hours for gliders and lighter than air aircraft were then subtracted (these hours were obtained from the Federal Aviation Administration publication *General Aviation and Air Taxi Activity Survey CY2001*, and similar previous publications). Flight hours for 2003 were estimated using the figures for 2002.

Other details on the characteristics and contributing factors of midair collisions in the US and other countries were obtained by reviewing previous publications.

Because midair collisions are statistically rare events, statistical tests of the difference in midair collision rate between time periods or countries were based on the Poisson distribution. Consistent with common convention, statistical significance was defined as the probability of the results occurring due to chance being less than 5%.

### **3. Characteristics of Australian midair collisions**

#### **3.1 Number of collisions**

The review identified 37 midair collisions involving general aviation aircraft in Australia during the 1961-2003 period.<sup>5</sup> Appendix A provides basic details on the 37 midair collisions.

Most (34) of the collisions were accidents rather than incidents. Table 1 provides details of the types of aircraft involved. Most of the collisions were between two aeroplanes.<sup>6</sup> Of the 65 aeroplanes involved, 60 were small single-engine aeroplanes, and the other five were twin piston-engine aircraft. The other nine aircraft involved in the collisions included one helicopter, seven gliders and one ultralight.

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<sup>3</sup> Accidents are events that result in more than minor damage or minor injury, whereas incidents can have minor or no damage or injury. A small percentage of midair collisions are not accidents.

<sup>4</sup> In the US, charter operations are known as 'aerial taxi' operations and are not considered to be general aviation. To keep consistency with the review of Australian accidents, aerial taxi operations were considered to be general aviation operations.

<sup>5</sup> Two collisions involving Australian registered aircraft, which occurred overseas, were also identified. One occurred in New Caledonia in 1971, and the other in New Zealand in 1999. Both involved aircraft deliberately flying close to each other, and neither resulted in fatalities.

<sup>6</sup> The term 'aeroplane' is used in this report to mean a registered fixed-wing aircraft.

Only one collision accident was identified during the period 1961-1968 (Moorabbin, 1968). The review was not able to identify whether or not there were any collision incidents between 1961 and 1968. Given that the vast majority of midair collisions after 1968 were accidents, it was considered unlikely that there were any collision incidents during the period 1961-1968.

In addition to the general aviation collisions, there were 26 collisions between registered sports aviation aircraft, most of them involving gliders (see Table 1).

**Table 1: Number of midair collisions in Australia between different types of aircraft between 1961 and 2003 (fatal accidents, non-fatal accidents, and incidents in brackets)**

Aircraft types	1961-70	1971-80	1981-90	1991-03	Total
<b>General aviation</b>					
Aeroplane-aeroplane	3 (0,3,0)	11 (3,7,1)	7 (4,2,1)	7 (4,2,1)	28 (11,14,3)
Aeroplane-helicopter	1 (1,0,0)	0	0	0	1 (1,0,0)
Aeroplane-ultralight	0	0	0	1 (0,1,0)	1 (0,1,0)
Aeroplane-glider	0	1 (1,0,0)	2 (2,0,0)	4 (4,0,0)	7 (7,0,0)
Total	4 (1,3,0)	12 (4,7,1)	9 (6,2,1)	12 (8,3,1)	37 (19,15,3)
<b>Sports aviation</b>					
Glider – glider	1 (1,0,0)	4 (1,2,1)	12 (2,7,3)	5 (3,1,1)	22 (7,10,5)
Balloon – balloon	0	0	2 (1,0,1)	2 (0,0,2)	4 (1,0,3)

### 3.2 Level of injury and damage

Nineteen of the accidents resulted in fatalities. For six of the accidents, there were fatalities from both aircraft. Overall there were 46 fatalities, with 28 occurring in aeroplane-aeroplane collisions, five involving aeroplane-helicopter collisions, and 13 involving aeroplane-glider collisions (including 10 from the aeroplanes). This equated to 1.2 fatalities per collision or 1.4 fatalities per collision accident. No one on the ground was fatally injured as a result of any of the collisions.

Of the 74 aircraft involved, 33 were destroyed. These included 27 aeroplanes, one helicopter, one ultralight and four gliders. Twenty of the aeroplanes were destroyed in aeroplane-aeroplane collisions, six in aeroplane-glider collisions, and one in an aeroplane-helicopter collision.

### 3.3 Location and type of operation

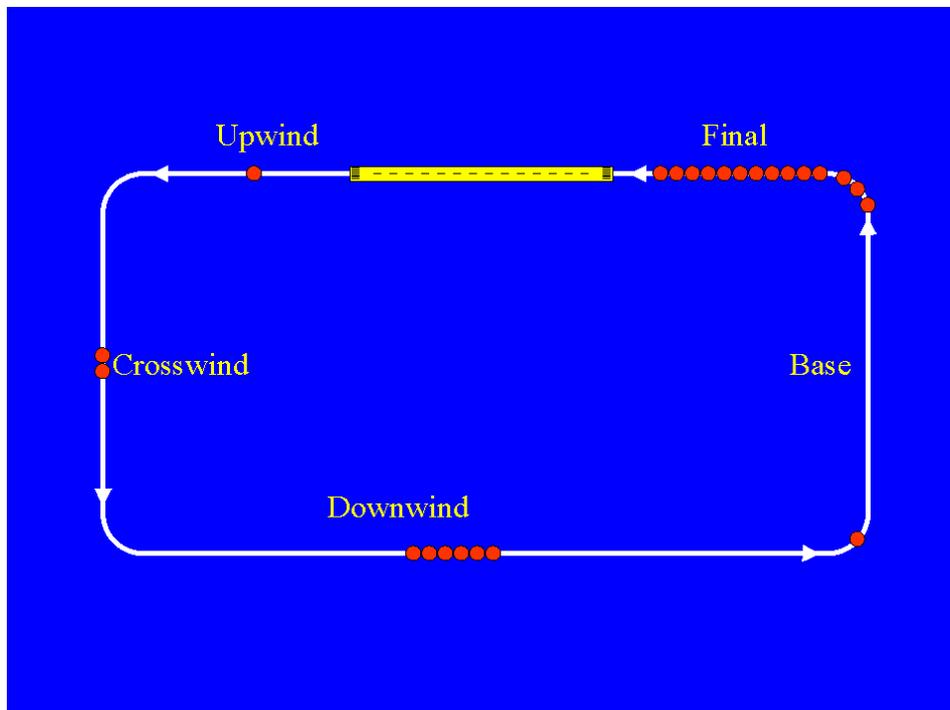
Table 2 presents basic data on the general location of the 37 collisions. Most (24) of the collisions occurred in the circuit area (that is, at least one of the aircraft was flying in the circuit pattern for landing or departure). These included 20 aeroplane-aeroplane collisions, one aeroplane-ultralight collision, and three aeroplane-glider collisions.

**Table 2: General location of collisions involving at least one registered powered aircraft in Australia between 1961 and 2003 (fatal accidents, non-fatal accidents, and incidents in brackets)**

Location/type	1961-70	1971-80	1981-90	1991-03	Total
Circuit area	3 (0,3,0)	8 (3,4,1)	4 (3,1,0)	9 (6,2,1)	24 (12,10,2)
Near circuit area	1 (1,0,0)	1 (1,0,0)	1 (1,0,0)	2 (2,0,0)	5 (5,0,0)
Enroute/airwork	0	1 (0,1,0)	1 (1,0,0)	0	2 (1,1,0)
Deliberately close	0	2 (0,2,0)	3 (1,1,1)	1 (0,1,0)	6 (1,4,1)
Total	4 (1,3,0)	12 (4,7,1)	9 (6,2,1)	12 (8,3,1)	37 (19,15,3)

Eleven of the collisions occurred when both aircraft were on final approach, two occurred during the base-to-final turn, and one occurred on the turn to base. The collision at Moorabbin in 1968 occurred either on the base leg or the final approach. Six collisions occurred on the downwind leg (one with an aircraft departing) and two occurred on the crosswind leg (one with an aircraft departing). One collision involved two aircraft on initial climb. Figure 1 presents a diagrammatic representation of the location of collisions in the circuit area. The dots indicate in which leg of the circuit the collisions occurred rather than the specific location within each leg.

**Figure 1: Diagrammatic representation of positions of midair collisions in the circuit area**



The diagram does not discriminate between left and right circuit patterns.

There were also five collisions that occurred near the circuit area (that is, within 5 NM of an airport and with at least one aircraft arriving at, or departing from, that airport). These included one aeroplane-aeroplane collision at 1,500 ft with both aircraft on departure, one aeroplane-helicopter collision at about 1,500-2,000 ft with both aircraft on arrival, and three aeroplane-glider collisions at less than 2,000 ft with the aeroplane climbing.

Of the 20 aeroplane-aeroplane collisions that occurred in or near the circuit area, 25 aeroplanes were on training flights, 12 were on private flights, two were on passenger charter flights, and one was on an aerial work flight. At least 21 of the aeroplanes were being used for circuit training or practice. The aeroplane-helicopter collision involved two aircraft on aerial work flights, and the aeroplane-ultralight collision involved two aircraft on private flights. The seven aeroplane-glider collisions involved five aeroplanes being used as glider tugs, although only one was actually towing a glider at or just prior to the accident. The other two aeroplanes were engaged in private and aerial work operations.

Fifteen of the collisions in or near the circuit area occurred at one of the five major general aviation airports; that is, Archerfield, Bankstown, Jandakot, Parafield or Moorabbin. Thirteen of these collisions occurred during tower operating hours<sup>7</sup>, although in one of these collisions neither pilot had yet contacted the tower (Moorabbin, 1970). Of the other two collisions, one (Jandakot, 2002) occurred just after the tower controllers had handed over to an air ground operator. The other collision (Moorabbin, 2002) occurred at night when the control zone was classified as a mandatory broadcast zone (MBZ). No other collisions have occurred in MBZs in Australia, which commenced in 1991.

Most (10) of the 15 collisions at the major general aviation airports occurred prior to the introduction of General Aviation Aerodrome Procedures (GAAP) during tower hours in 1980.<sup>8</sup> The major change to operations at these airports in 1980 was the introduction of simultaneous contra-rotating circuit operations onto parallel runways (contra-circuits) at those airports with parallel runways. The previous procedures (known as a secondary control zone) involved all aircraft flying circuits in the same direction on the same side of the runways. Due to the high aircraft movement rates, tower controllers were only required to provide a limited service at secondary/GAAP airports, with aircraft separation being primarily a pilot responsibility. A review of the 10 collisions that occurred prior to 1980 found that many of them were unlikely to have occurred if contra-circuit operations to parallel runways had been in use. Only one of the 37 collisions occurred in controlled airspace where air traffic services were providing a full control service. This collision occurred in the Coolangatta primary control zone in May 1988.

There were six collisions involving pilots deliberately flying close to another aircraft. All were aeroplane-aeroplane collisions, and four involved formation flying activities.

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<sup>7</sup> Due to the high movement rates and the types of operations at these airports during tower hours, tower controllers were only required to provide a limited service. Aircraft separation was primarily a pilot responsibility.

<sup>8</sup> GAAP commenced at Parafield in 1978 and at the other five airports during 1980. The level of air traffic control service was similar both before and after the introduction of GAAP.

Seven of the aircraft were operating in the private category, two in the aerial work category, and three in the charter category.<sup>9</sup>

Only two other collisions occurred away from the circuit area. One involved two aeroplanes on private sightseeing flights (at 1,500 ft), and the other involved two aerial agricultural aeroplanes about to commence swathe runs (at approximately 50 ft).

It is not surprising that most of the collisions occurred in the circuit area, as this is generally where the traffic density is the highest. Of particular note is that at least 11 of the collisions in the circuit area occurred on final approach, where there is relatively little variation in the position of aircraft.

### 3.4 Other characteristics and contributing factors

The 30 midair collisions since 1969 not involving 'deliberately close' activities were reviewed to identify common characteristics and contributing factors. The 1968 collision at Moorabbin could not be included due to a lack of information. This review noted that there was a wide variety of contributing factors in the collisions, but there were no dominant factors. The circumstances of the majority of the collisions were consistent with the inherent difficulties in sighting aircraft in time to avoid a collision.<sup>10</sup> More specifically, the review noted the following:

- All of the collisions occurred during good weather conditions, with visibility being 10 km or more (when recorded). There were no reports that problems with visibility contributed to any of the collisions. Only one of the collisions occurred at night (Moorabbin, 2002). Sun glare was cited as a possible factor in four of the collisions.
- Most (18) of the collisions involved one aircraft colliding with another from behind, or both aircraft converging from a similar direction (less than 30 degrees difference in heading), and only six of these collisions resulted in fatalities. Twelve of these collisions occurred at a height of 250 ft or less above the ground, with only three resulting in fatalities. Of the 12 collisions with collision angles 30 degrees or greater, 11 resulted in fatalities.<sup>11</sup> All of these collisions occurred at heights greater than 250 ft. Figure 2 provides a diagrammatic representation of the collision angles involved in the midair collisions.
- At least eight of the aeroplane-aeroplane collisions involved pilots conducting different sized circuits, but none of the pilots flew paths that were considered to be contrary to procedures. Two of the aeroplane-glider collisions involved glider pilots conducting unusual circuit patterns, with one of them entering the circuit from the wrong direction. The Bankstown collision in May 2002 was the only collision involving contra-circuit operations to parallel runways.

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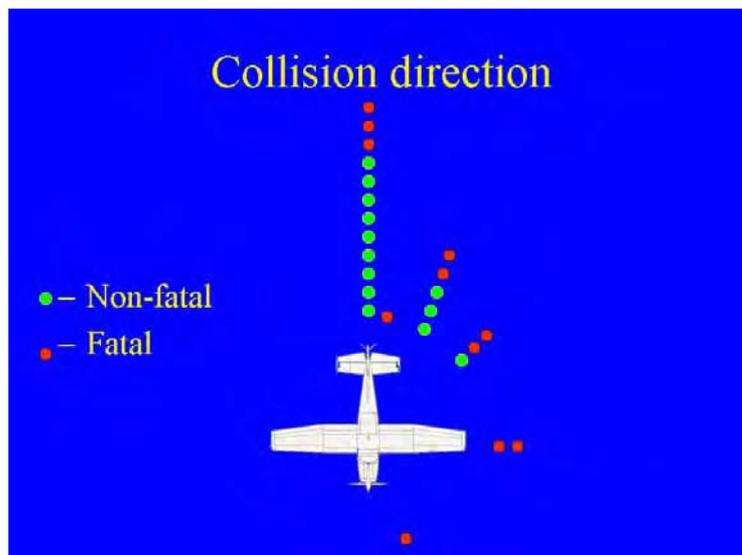
<sup>9</sup> Two of these were Pitts S2A aircraft involved in a simulated World War One air combat scenario (near Bankstown, 2003).

<sup>10</sup> The difficulties in detecting aircraft are reviewed in the Bureau of Air Safety Investigation (BASI) 1991 research report *Limitations of the See-and-Avoid Principle*. BASI became part of the newly formed Australian Transport Safety Bureau (ATSB) on 1 July 1999.

<sup>11</sup> One of the 'deliberately close' collisions involved a difference in headings of 30 degrees, and this collision also resulted in a fatality.

- A pilot not using his radio to communicate was cited as a possible contributing factor in one of the aeroplane-aeroplane collisions at a non-towered aerodrome, with the pilot not making a base broadcast due to congestion on the radio frequency at the time. In the majority of the other collisions, there was evidence to suggest that pilots had made the appropriate radio broadcasts. In at least six of the aeroplane-aeroplane collisions, one or both of the pilots did not hear a radio broadcast made by the other pilot. Both pilots were not using radios in three of the aeroplane-glider collisions, and the glider pilot did not make appropriate broadcasts in another two of the collisions. In another aeroplane-glider collision, the aeroplane pilot did not broadcast on the glider frequency.<sup>12</sup>
- In at least six of the collisions, pilots were provided with and were aware of traffic information, but it was at least moderately likely that the pilot identified the wrong aircraft.
- Actions by air traffic control personnel were directly involved in the midair collision in the Coolangatta control zone in May 1988. Controllers not providing adequate traffic information probably also contributed to at least three of the collisions at the major general aviation airports.
- High pilot workload or distractions were cited as a possible factor in at least three of the collisions. It is also likely that, in many of the other collisions, workload in the circuit area reduced the time available for searching for unknown traffic.
- Cockpit visibility restrictions would have reduced the ability of at least one of the pilots to see the other aircraft during some of the later stages for many of the collisions. For example, on final approach there are usually significant cockpit visibility restrictions on one or both pilots seeing the other aircraft.

**Figure 2: Diagrammatic representation of collision angles involved in collisions not involving deliberately close flying activities**



The diagram does not include collisions with gliders, or collisions where aircraft were flying deliberately close.

<sup>12</sup> The then Bureau of Air Safety Investigation (BASl) has made recommendations regarding the use of radios by gliding operations. BASl was incorporated into the new Australian Transport Safety Bureau from July 1999.

### 3.5 Australian midair collision rates

Table 3 presents accident statistics for midair collision accidents involving general aviation aircraft in Australia over the period 1961 to 2003. Overall, the number of events and hours in the 1961-1970 period was considered too low for meaningful analysis, so the data for this period were combined with the 1971-1980 period in Table 3.<sup>13</sup>

**Table 3: Midair collision accident rates for Australia for general aviation operations**

	<b>1961-1980</b>	<b>1981-1990</b>	<b>1991-2003</b>
Hours per year (100,000s)	10.20	16.44	17.49
Total hours flown in the period (100,000s)	204.0	164.4	227.37
Midair collision accidents	15	8	11
Midair collision accidents per 100,000 hours	0.074	0.049	0.048
Number of general aviation aircraft involved	29	14	17
Hours per collision for general aviation aircraft	700,000	1,170,000	1,340,000
Fatal midair collision accidents	5	6	8
Fatal midair collision accidents per 100,000 hours	0.025	0.036	0.035

The overall midair collision accident rate was higher in the period 1961-1980 (0.074 per 100,000 flight hours) compared with the subsequent period 1981-2003 (0.048 per 100,000 flight hours), but the difference was not statistically significant.<sup>14</sup>

To get a better assessment of the risk level for general aviation operations, the review also examined the number of hours flown per collision for general aviation aircraft (that is, the number of hours flown divided by the number of general aviation aircraft involved in collision accidents). The hours flown per collision was lower (meaning more risk) in the period 1961-1980 (700,000 hours) compared with the subsequent period 1981-2003 (1,260,000 hours), and this difference was statistically significant.<sup>15</sup> This decrease in risk may be associated with a decrease in the rate of collisions at the major general aviation airports following the introduction of GAAP.

Midair collisions accounted for 0.4 per cent of all accidents involving registered powered aircraft in Australia during 1969-2003 (0.4 per cent in the period 1981-2003). Midair collisions also accounted for 2.7 per cent of all fatal aircraft accidents involving such aircraft in Australia during 1969-2003 (2.9 per cent in the period 1981-2003).

<sup>13</sup> Hours flown steadily increased from about 370,000 hours in 1961 to about 1,000,000 hours in 1967, and then remained at that level until about 1972 before starting to increase again.

<sup>14</sup> Poisson analysis: rate ratio = 1.52, probability = 0.2, 95 % confidence interval 0.77 to 2.98.

<sup>15</sup> For the statistical tests, rates were based on number of general aviation aircraft involved per 100,000 flight hours. Poisson analysis: rate ratio = 1.80, probability = 0.02, 95 % confidence interval 1.08 to 2.98.

The proportion of midair collision accidents that resulted in fatalities was lower in the period 1961-1980 (33 per cent) than in the period 1981-2003 (74 per cent).<sup>16</sup> Most of the collisions at or below 250 ft above the ground occurred before 1981 (eight collisions, two with fatalities), and many of them (five collisions, one with fatalities) occurred at the major general aviation airports before the implementation of GAAP. In addition, there was an increase in aeroplane-glider collisions after 1980. All of the aeroplane-glider collisions were fatal, and five (four after 1980) of them involved a difference in headings of 30 degrees or more.

Most of the midair collision accidents involved private, business or training operations. The accident rate for these operations was 0.11 and 0.08 per 100,000 hours for the 1961-1980 and 1981-2003 periods respectively. The hours flown per collision for private, business and training operations was 560,000 for 1961 to 1980 and 770,000 for 1981 to 2003.

For the period 1981-2003, there were 19 collision accidents involving gliders. The rate of accidents was 1.11 per 100,000 hours flown.<sup>17</sup> The number of hours flown per collision for gliders was 54,000 hours, which was 25 times lower than the rate for general aviation operations (1,350,000 hours per collision for the same period).

#### 4. Characteristics of midair collisions in other countries

##### 4.1 Midair collisions in the United States (US)

Table 4 presents midair collision accident statistics for general aviation in the US over the period 1981-2003. Only general aviation flight hours were considered as there were only eight RPT aircraft involved in the collisions (one high capacity), with only one being involved in a collision in the period 1991-2003. There were no collisions involving two RPT aircraft. There were 11 collisions between a general aviation aircraft and a sports aviation aircraft, and 15 collisions between a general aviation aircraft and a military aircraft.

**Table 4: Midair collision accident rates for the US for general aviation operations**

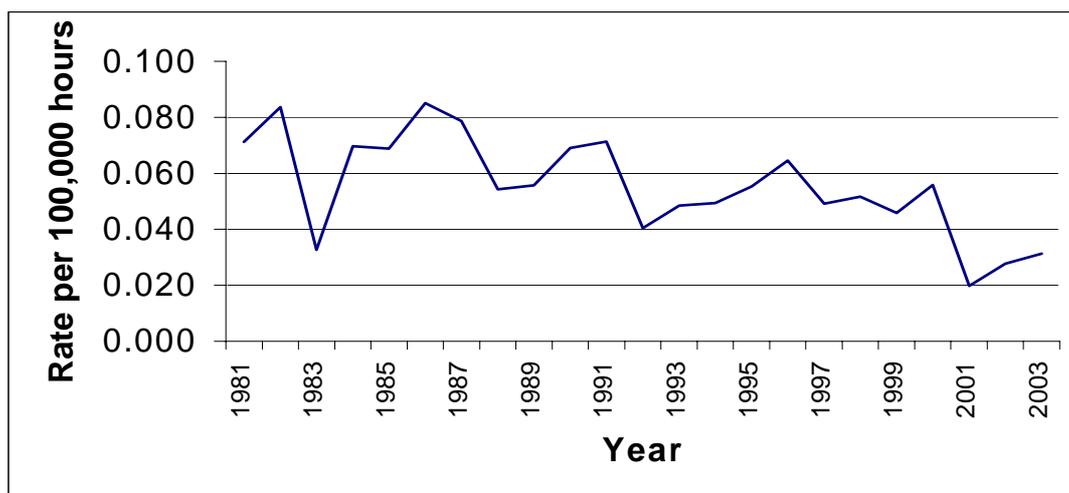
	<b>1981-1990</b>	<b>1991-2003</b>
Hours per year (100,000s)	313.42	285.26
Total hours flown in the period (100,000s)	3134.2	3708.4
Midair collision accidents	210	174
Midair collision accidents per 100,000 hours	0.067	0.047
Number of general aviation aircraft involved	402	331
Hours per collision for general aviation aircraft	780,000	1,120,000
Fatal midair collision accidents	122	103
Fatal midair collision accidents per 100,000 hours	0.040	0.028

<sup>16</sup> Fisher exact probability test,  $p = 0.01$ .

<sup>17</sup> Hours flown data for gliders was only available for 1981 to 1998. Data for the other years were estimated based on data for adjacent years.

Figure 3 shows the rate of midair collision accidents per 100,000 flight hours in the US for the period 1981-2003. The rate appears to have decreased over that period. A comparison of the rate between the period 1981-1990 and 1991-2003 was statistically significant.<sup>18</sup> The reasons for the decrease in midair collision rate involving general aviation aircraft are not known.

**Figure 3: Rate of midair collision accidents for the US per 100,000 flying hours for the period 1981-2003**



In terms of general location of midair collision accidents in the US between 1981 and 2003, 16 could not be classified due to a lack of information. Of the remaining 368 accidents, 169 (46 per cent) occurred in the circuit area, and 56 (15 per cent) occurred near the circuit area. Of the remainder of the US collisions, 46 (13 per cent) involved 'deliberately close' flying, and 97 (26 per cent) occurred away from the circuit area. These rates were essentially the same for the periods 1981-1990 and 1991-2003.

Most of the accidents in the circuit area involved one or both aircraft on final approach. Fifty-nine (26 per cent) of the accidents in or near the circuit area occurred at airports with a tower. The accidents away from the circuit area involved a mix of both aircraft in cruise flight, one or both aircraft climbing from or descending to an airport, or both aircraft involved in airwork activities.

Of the 384 midair collision accidents in the US, 225 (59 per cent) involved fatalities. There was a total of 754 fatalities (or 2.0 fatalities per accident). If the accidents involving RPT aircraft are excluded, there were 220 fatal accidents and a total of 628 fatalities (or 1.6 fatalities per accident).

The US Federal Aviation Administration (FAA) recently conducted a similar review of midair collisions in the US for the period between 1983 and August 2000, involving a total of 329 collisions.<sup>19</sup> Findings of this review included the following:

<sup>18</sup> Difference in midair collision accidents per 100,000 flight hours, Poisson analysis: rate ratio = 1.43, probability < 0.001, 95 % confidence interval 1.17 to 1.75. Difference in rate of general aviation aircraft involved per 100,000 flight hours, Poisson analysis: rate ratio = 1.44, probability < 0.001, 95 % confidence interval 1.24 to 1.66.

<sup>19</sup> R. C. Mathews 'Characteristics of U.S. Midairs', *FAAviation*, May-June 2001.

- All occurred in visual meteorological conditions. Only six occurred at night and four occurred at dusk. Bright sun was on the only commonly sighted factor related to weather.
- About 88 per cent of pilots involved in midair collisions do not see the other aircraft in time to avoid a collision.
- Most midair collisions involve low closing speeds, as one aircraft usually strikes the other from behind, above or from a quartering angle.
- Most midair collisions occur near airports, especially airports without a control tower. Midair collisions at high altitudes are rare events.
- A common factor in midair collisions was pilots using inappropriate entries into the circuit and failing to use radios at non-towered airports.
- The 329 midair collisions indicate that see-and-avoid has inherent limitations as a tactic or strategy for avoiding midair collisions.

Morris<sup>20</sup> also conducted a review of midair collisions in the US from 1991 to 2000. His review was based on 158 collisions.<sup>21</sup> Morris's findings for the 158 collisions included:

- The sky condition was clear for 67 per cent of the collisions and broken/overcast for 33 per cent.
- Seventy-six per cent were 'airport involved'. Exactly what was meant by his term was not clear. Over the same period, the ATSB classified 60 per cent as occurring in or near the circuit area (that is, within 5 NM of the airport).
- Fifty-nine per cent (92) were classified as occurring in the traffic pattern, with just under half of these occurring on final approach.<sup>22</sup>
- Of the 92 collisions classified as occurring in the traffic pattern, 27 per cent involved a failure to use the radio, 22 per cent involved a failure to use procedures, 18 per cent involved air traffic control errors and nine per cent involved sun glare.
- In 88 per cent of the collisions, one or both aircraft were manoeuvring at the time of collision.
- Most of the collisions in the traffic pattern involved the two aircraft colliding head to tail or at an acute angle. About half of the collisions away from the traffic pattern involved the two aircraft colliding head to tail or at an acute angle, with the other half occurring at an oblique angle or head to head.

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<sup>20</sup> C. C. Morris, *Current analysis of hazard factors in US civil aviation midair collisions, 1991-2000*, paper presented at the Association for Public Policy Analysis and Management, November 2003.

<sup>21</sup> The ATSB review examined only 151 collisions for this period. The ATSB review excluded three collisions that were not accidents, two glider-glider collisions and two balloon-balloon collisions.

<sup>22</sup> The ATSB review classified 47 per cent (81) as occurring in the circuit. The reason for the different classifications was not clear, although Morris's review probably had a broader definition of what constituted a traffic pattern. The ATSB review used the same criteria as it used for classifying the Australian occurrences.

## 4.2 Midair collisions in other countries

The Bureau d'Enquetes et d'Analyses pour la Securite de l'Aviation Civile conducted a review of midair collisions that occurred in French territory between 1989 and 1999 and involved at least one civil aircraft.<sup>23</sup> The review excluded formation flights and glider-glider collisions. Results of the review provided included:

- There were 17 collisions, which resulted in 42 fatalities and 27 aircraft destroyed. Air transport aircraft were involved in three collisions, and gliders were involved in four collisions.
- All of the collisions occurred during daylight in visual meteorological conditions. In two cases, pilots reported poor visibility conditions, and in six cases one of the pilots had 'the sun in his face'.
- Seven of the collisions occurred near an aerodrome with aircraft in the circuit. Another eight collisions took place in areas where aircraft concentration was high, such as near an aerodrome, overhead a radio navigation device, or where there were a large number of gliders. Only two occurred during cruise.
- Twelve collisions occurred in uncontrolled airspace and the remaining five in controlled airspace, although communication was not compulsory for three of these situations. Non-use of radios or other communication problems was an issue with several of the collisions. Only one of the aircraft did not have a radio.

In a recent accident investigation report,<sup>24</sup> the Transportation Safety Board of Canada noted that in the 10 years prior to August 1999, there were 17 midair collisions in Canada. Of these, '8 involved some form of formation flight, 3 occurred in practice training areas, and 6 occurred in the vicinity of uncontrolled airports'. None occurred in a control zone where an advanced level of air traffic control was being provided.

## 5. Comparison of collision rates between Australia and the US

There were no midair collisions involving RPT aircraft in Australia during the period 1961-2003. Consequently, it was not possible to compare collision risk between Australia and the US for RPT aircraft using actual collisions.

Figure 4 shows a comparison of the midair collision accident rate per hours flown for general aviation aircraft in Australia and the US. The figure indicates that the US may have had a higher rate of collisions during the period 1981-1990, but the two countries had a similar rate during the period 1991-2003. Overall, the difference between the two countries for the period 1981-2003 (0.048 in Australia and 0.056 in US) was not statistically significant.<sup>25</sup>

Figure 5 shows a comparison between Australia and the US in terms of the hours flown per collision for general aviation aircraft. Overall, for the period 1981-2003, the US had a lower number of hours flown per collision (930,000 hours) for general aviation aircraft relative to Australia (1,260,000 hours), indicating that general

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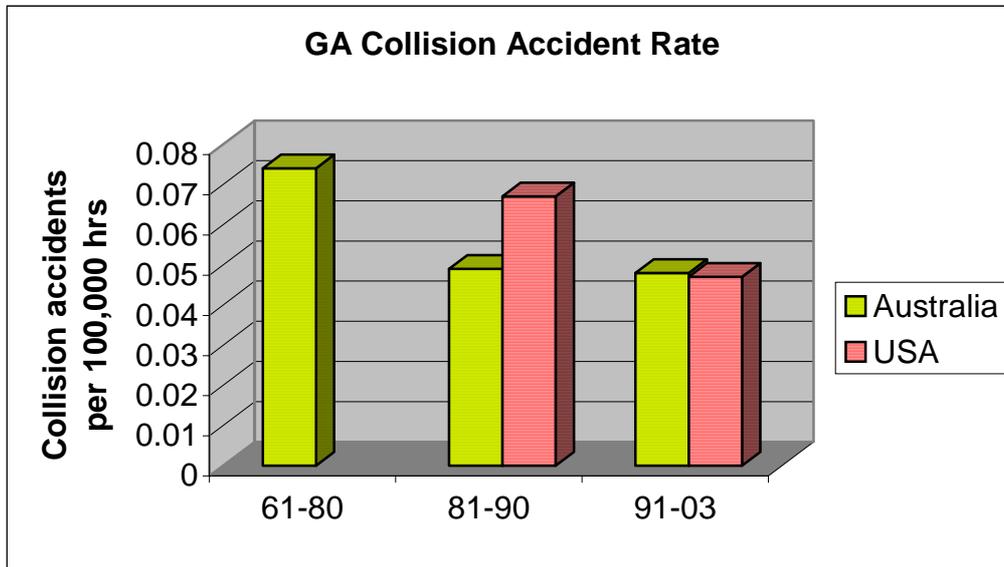
<sup>23</sup> Bureau d'Enquetes et d'Analyses pour la Securite de l'Aviation Civile, Safety Study, *Mid-air collisions 1989-1999*.

<sup>24</sup> Transportation Safety Board of Canada, Accident Investigation Report A99P0108, *Midair collision between Cessna 177RG Cardinal C-GWYY and Mooney M20C C-GASL*, Penicton, British Columbia, 20 August 1999.

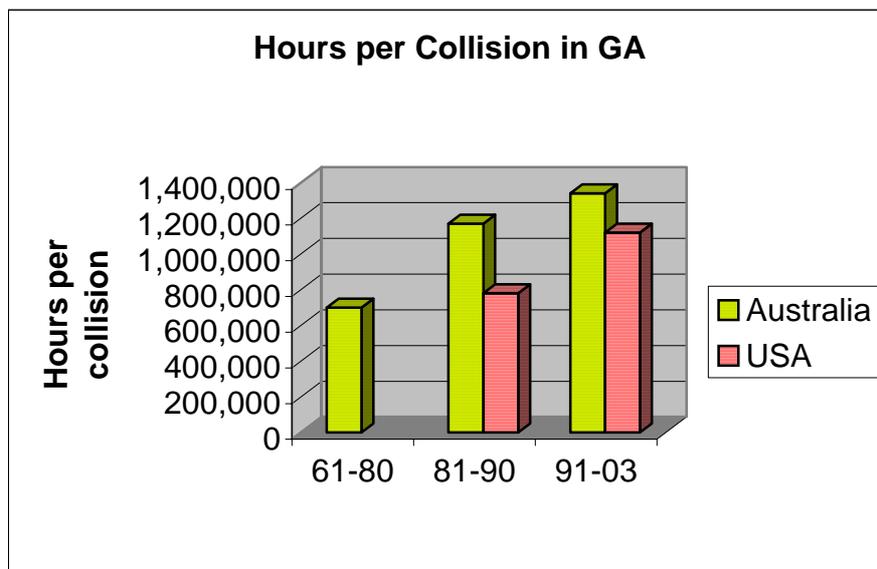
<sup>25</sup> Poisson analysis: rate ratio = 0.86, probability = 0.5, .95 % confidence interval 0.55 to 1.37.

aviation in the US may have had a slightly higher risk for midair collisions. However, this difference was not statistically significant.<sup>26</sup>

**Figure 4: Comparison of midair collision accident rate between Australia and the US for general aviation**



**Figure 5: Comparison of flight hours per collision between Australia and the US for general aviation aircraft**



<sup>26</sup> Poisson analysis: rate ratio = 0.74, probability = 0.1, 95 % confidence interval 0.52 to 1.06.

Comparisons of midair collision rates between two countries or areas need to consider a range of factors, most importantly traffic density. The FAA has stated that collisions between aircraft are best explained as a function of the square of the number of aircraft movements.<sup>27</sup> In general, the traffic density is higher near airports than away from airports. Therefore, it would be more appropriate to consider whether there was a difference in the collision rates in or near the circuit area as well as away from the circuit area.

Unfortunately, there were no figures available for the number of hours flown or number of movements in or near the circuit area versus away from the circuit area for either Australia or the US. Based on the assumption that the proportion of flying in or near the circuit area was the same in Australia and the US, it was found that:

- Australia had a general aviation midair collision accident rate 1.1 times higher than that of the US in or near the circuit area during the period 1981-2003. This comparison excluded collisions involving aircraft deliberately flying close to each other. This difference was not statistically significant.<sup>28</sup>
- The US had a general aviation midair collision accident rate 5.8 times higher than that of Australia away from the circuit area during the period 1981-2003. This comparison excluded collisions involving aircraft deliberately flying close to each other. The test of the difference between the two countries was not significant.<sup>29</sup> However, this test had a low level of power to detect differences in the rates as the Australian rate was based on only one event (Moreton Bay, 1988). The fact that only one event also occurred during the period 1961-1980 (Cecil Plains, 1980) suggests that the Australian rate may be reasonably reliable. There was a significant difference in the hours flown per collision involving general aviation between the two countries, indicating that there was a higher collision risk in the US away from the circuit area relative to Australia.<sup>30</sup>

It would be reasonable to expect that the US had a higher rate of collisions per flight hour away from the circuit area as it is generally accepted that it has a higher traffic density in this airspace relative to Australia. For example, the US had 17.5 times more general aviation flight hours than Australia during the period 1981-2003. However, quantifying the difference in traffic density is a complex issue and beyond the scope of this study. The extent of any difference in the average traffic density for general aviation aircraft in or near the circuit area between the two countries was also beyond the scope of this review.

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<sup>27</sup> FAA, *Establishment and Discontinuance Criteria for Airport Traffic Control Towers*, Report No. FAA-APO-90-7, August 1990.

<sup>28</sup> Difference in midair collision accidents per 100,000 flight hours, Poisson analysis: rate ratio = 1.12, probability = 0.7, 95 % confidence interval 0.66 to 1.88. Difference in rate of general aviation aircraft involved per 100,000 flight hours, Poisson analysis: rate ratio = 0.89, probability = 0.6, 95 % confidence interval 0.58 to 1.35.

<sup>29</sup> Poisson analysis: rate ratio = 0.17, probability = 0.08, 95 % confidence interval 0.02 to 1.24.

<sup>30</sup> Poisson analysis: rate ratio = 0.19, probability < 0.05, 95 % confidence interval 0.05 to 0.76.



<b>ATSB Occurrence Number</b>	<b>Date</b>	<b>Location</b>	<b>Description</b> <b>Note: type of operation, phase of flight and location of collision are shown in brackets.</b>
197902791	08/06/1979	Warrnambool	Cessna C150 (training, arriving, final) collided with Cessna A150 (training, circuits, final) when the A150 pulled up in front of the C150 (150 ft). Radio call missed because of radio traffic. Fatal accident
198000027	04/05/1980	Cecil Plains	Cessna A 188 (agricultural, en route) Collided with Cessna A188 (agricultural, en route) while transiting from a farm to an airfield (50ft). Non-fatal accident
198002609	28/09/1980	Moorooduc	Cessna C 172 (private, arriving, joining circuit downwind) collided with glider (joining circuit downwind) at 170 degrees. Fatal accident.
198102970	02/17/1981	Near Cranbourne	Cessna C152 (private, formation flight) collided with Cessna C152 (private, formation flight). Deliberately close flying. Incident.
198601425	10/07/1986	Benalla	Piper PA-25 (tug, arriving, joining circuit downwind) collided with glider (circuit, downwind) from above and behind (700 ft). Fatal accident
198801381	16/01/1988	Near Portsea	Pitts S2A (private, formation flight) collided with Pitts S2A (private, formation flight). Deliberately close flying. Fatal accident.
198803454	24/04/1988	Archerfield airport	Piper PA-28 (private, circuits, turning onto base) collided with Cessna 150 (training, circuits, turning onto base) from behind (1,000 ft). Fatal accident.
198803460	20/05/1988	Coolangatta	Cessna C 172 (training, circuits, downwind) collided with Piper PA-38 (training, circuits, conducting an orbit) at 90 degrees, (1,000 ft) in primary controlled airspace. Fatal accident.
198803474	07/08/1988	Moreton Bay, enroute	Piper PA-28 (scenic flight) collided with Piper PA-28 (scenic flight) in opposite direction turns at 20 degrees (1,500 ft). Fatal accident
198900238	29/05/1989	Jandakot	Cessna 152 (training, circuits, base-to-final turn) collided with Cessna 152 (training, arriving for circuits, base-to-final turn) from behind (500 ft). Non-fatal accident.
199003061	25/04/1990	Near Blacksmith	Piper PA-31 (charter) collided with Cessna C210 in the same direction when attempting to scare the pilot. Non-fatal accident.
199002021	02/11/1990	Tocumwal	Beechcraft V35A (aerial work, departing, climbing) collided with glider (circling, thermalling) at 35 degrees (1,700 ft). Fatal accident
199100010	12/04/1991	Mudgee	Piper PA-28 (training, solo navigational exercise, arriving) collided with Piper PA-28 (training, solo navigational exercise, departing the circuit) from behind (1,000ft). Fatal accident.
199200011	08/02/1992	Tocumwal	8GCBC (Tug, circuit, final) collided with glider (close oblique base) converging at 5 degrees (300 ft). Fatal accident.
199201988	15/07/1992	Hoxton Park	Piper PA-28 (training, solo circuits, short final) collided with Beechcraft C 23 (training, arriving, short final) in the same direction (10 ft). Incident.
199202599	01/11/1992	Jondarayan	Piper PA-25 (tug, just released aerotow) collided with glider (just released from aerotow), converging at 5 degrees (1,600 ft). Fatal accident.

<b>ATSB Occurrence Number</b>	<b>Date</b>	<b>Location</b>	<b>Description</b> <b>Note: type of operation, phase of flight and location of collision are shown in brackets.</b>
199303898	24/11/1993	Benalla	Piper PA-25 (tug, circuit, late downwind/early base) collided with glider (circuit, late downwind/early base) almost head on (750 ft). Fatal accident.
199802022	06/06/0998	Hoxton Park	Piper PA-28 (private, arriving, joining circuit crosswind) collided with Piper PA-38 (private, arriving, joining circuit crosswind) at 90 degrees (1,200 ft). Fatal accident.
199900844	02/03/1999	Waikerie	Piper PA-25 (tug, climbing with aerotow) collided with glider (en route) at 30 degrees (1,500 ft). Fatal accident.
200004070	18/09/2000	Merredin	Grob G-115 (training, circuits, short final) collided with Grob G-115 (training, circuits, short final) in the same direction (30 ft). Non-fatal accident.
200200548	22/02/2002	Jandakot	Cessna 172 (private, arriving, final) collided with ultralight (private, arriving, final) from behind (10 ft). Tower closed. Non-fatal accident.
200201846	05/05/2002	Bankstown	Piper PA-28 (private, arriving, base-to-final turn) collided with Socata TB-9 (training, circuits, final) (450 ft). Fatal accident.
200203449	29/07/2002	Moorabbin	Cessna 172 (training, circuits, final) collided with Cessna 172 (training, circuits, final) from behind (30 ft). Tower closed. Fatal accident.
200302183	10/05/2003	Warragamba	Pitts S2A (charter, formation aerobatic flight) collided with Pitts S2A (charter, formation aerobatic flight). Deliberately close flying. Non-fatal accident.

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**May 2004**

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