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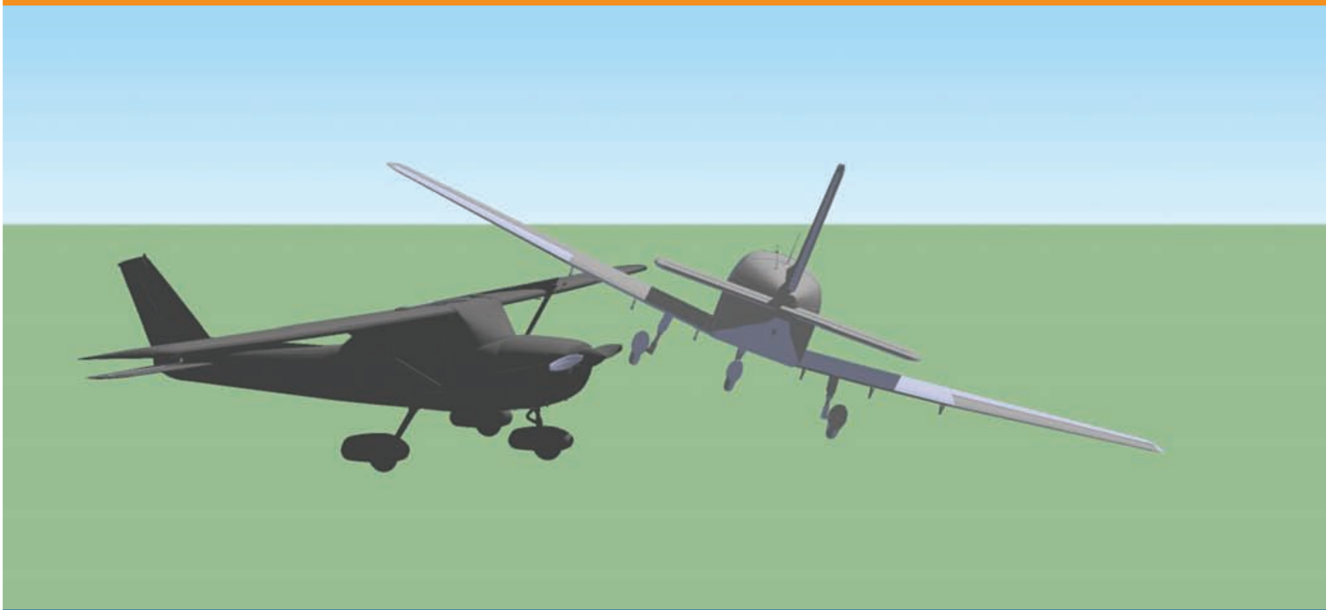

ATSB TRANSPORT SAFETY REPORT
Aviation Occurrence Investigation
AO-2008-059
Final

Midair collision
3 km NW of Moorabbin Airport, Vic
27 August 2008
VH-UPY, Cessna Aircraft A150M and VH-CGT, Piper Aircraft PA-28-161

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Midair collision –3 km NW of Moorabbin Aerodrome, Victoria – 27 August 2008 - VH-UPY, Cessna Aircraft Company A150M and VH-CGT, Piper Aircraft Corp PA-28-161

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Abstract

On 27 August 2008 at 1238 Eastern Standard Time, a solo student pilot in a Cessna Aircraft Company A150M aircraft, registered VH-UPY (UPY), and a student pilot and instructor in a Piper Aircraft Corp PA-28-161 aircraft, registered VH-CGT (CGT), were flying about 3 km north-west of Moorabbin Aerodrome, Victoria.

The pilot of UPY conducted a touch-and-go on runway 31 left (31L) at Moorabbin as CGT was entering the control zone from the north-west at 1,000 ft above mean sea level (AMSL) to join the circuit on left downwind for runway 31L. As CGT approached the circuit pattern, the student pilot saw UPY, very close and climbing from his left on a collision course, and took avoiding action. However, the two aircraft collided, resulting in UPY colliding with terrain and fatal injuries to the solo student pilot.

In the time leading up to the collision, the air traffic controller workload had been high and relevant traffic information was not issued to the pilots in sufficient time to assist self-separation. The investigation identified that the design of the then Moorabbin Aerodrome General Aviation Aerodrome Procedures (GAAP) airspace did not provide lateral or vertical separation between traffic flows, and that this increased the risk of a midair collision. In addition, Airservices Australia (Airservices) had not acted on a number of internal recommendations to manage a gradual increase in operations at Moorabbin.

As a result of this investigation, Airservices have undertaken a review of their internal processes for reviewing safety performance. In addition, as a result of a number of midair collisions in the vicinity of GAAP aerodromes, the Civil Aviation Safety Authority (CASA) undertook several reviews of GAAP leading to improved training procedures and, as an interim measure, restrictions on the number of aircraft in the circuit. On 3 June 2010, CASA implemented Class D airspace procedures at all GAAP aerodromes throughout Australia.

THE AUSTRALIAN TRANSPORT SAFETY BUREAU

The Australian Transport Safety Bureau (ATSB) is an independent Commonwealth Government statutory agency. The Bureau is governed by a Commission and is entirely separate from transport regulators, policy makers and service providers. The ATSB's function is to improve safety and public confidence in the aviation, marine and rail modes of transport through excellence in: independent investigation of transport accidents and other safety occurrences; safety data recording, analysis and research; fostering safety awareness, knowledge and action.

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 identify and reduce safety-related risk. ATSB investigations determine and communicate the safety factors related to the transport safety matter being investigated. The terms the ATSB uses to refer to key safety and risk concepts are set out in the next section: Terminology Used in this Report.

It is not a function of the ATSB to apportion blame or determine liability. At the same time, 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 initiate proactive safety action that addresses safety issues. Nevertheless, the ATSB may use its power to make a formal safety recommendation either during or at the end of an investigation, depending on the level of risk associated with a safety issue and the extent of corrective action undertaken by the relevant organisation.

When safety recommendations are issued, they focus on clearly describing the safety issue of concern, rather than providing instructions or opinions on a preferred method of corrective action. As with equivalent overseas organisations, the ATSB has no power to enforce the implementation of its recommendations. It is a matter for the body to which an ATSB recommendation is directed to assess the costs and benefits of any particular means of addressing a safety issue.

When the ATSB issues a safety recommendation to a person, organisation or agency, they must provide a written response within 90 days. That response must indicate whether they accept the recommendation, any reasons for not accepting part or all of the recommendation, and details of any proposed safety action to give effect to the recommendation.

The ATSB can also issue safety advisory notices suggesting that an organisation or an industry sector consider a safety issue and take action where it believes it appropriate. There is no requirement for a formal response to an advisory notice, although the ATSB will publish any response it receives.

TERMINOLOGY USED IN THIS REPORT

Occurrence: accident or incident.

Safety factor: an event or condition that increases safety risk. In other words, it is something that, if it occurred in the future, would increase the likelihood of an occurrence, and/or the severity of the adverse consequences associated with an occurrence. Safety factors include the occurrence events (e.g. engine failure, signal passed at danger, grounding), individual actions (e.g. errors and violations), local conditions, current risk controls and organisational influences.

Contributing safety factor: a safety factor that, had it not occurred or existed at the time of an occurrence, then either: (a) the occurrence would probably not have occurred; or (b) the adverse consequences associated with the occurrence would probably not have occurred or have been as serious, or (c) another contributing safety factor would probably not have occurred or existed.

Other safety factor: a safety factor identified during an occurrence investigation which did not meet the definition of contributing safety factor but was still considered to be important to communicate in an investigation report in the interests of improved transport safety.

Other key finding: any finding, other than that associated with safety factors, considered important to include in an investigation report. Such findings may resolve ambiguity or controversy, describe possible scenarios or safety factors when firm safety factor findings were not able to be made, or note events or conditions which ‘saved the day’ or played an important role in reducing the risk associated with an occurrence.

Safety issue: a safety factor that (a) can reasonably be regarded as having the potential to adversely affect the safety of future operations, and (b) is a characteristic of an organisation or a system, rather than a characteristic of a specific individual, or characteristic of an operational environment at a specific point in time.

Risk level: The ATSB’s assessment of the risk level associated with a safety issue is noted in the Findings section of the investigation report. It reflects the risk level as it existed at the time of the occurrence. That risk level may subsequently have been reduced as a result of safety actions taken by individuals or organisations during the course of an investigation.

Safety issues are broadly classified in terms of their level of risk as follows:

- **Critical** safety issue: associated with an intolerable level of risk and generally leading to the immediate issue of a safety recommendation unless corrective safety action has already been taken.
- **Significant** safety issue: associated with a risk level regarded as acceptable only if it is kept as low as reasonably practicable. The ATSB may issue a safety recommendation or a safety advisory notice if it assesses that further safety action may be practicable.
- **Minor** safety issue: associated with a broadly acceptable level of risk, although the ATSB may sometimes issue a safety advisory notice.

Safety action: the steps taken or proposed to be taken by a person, organisation or agency in response to a safety issue.

FACTUAL INFORMATION

History of the flights

On 27 August 2008 at 1238 Eastern Standard Time,[1] a Cessna Aircraft Company (Cessna) A150M aircraft, registered VH-UPY (UPY), and a Piper Aircraft Corp (Piper) PA-28-161 aircraft (PA-28), registered VH-CGT (CGT), were flying 3 km north-west of Moorabbin Aerodrome, Victoria.

The student pilot of UPY was carrying out a number of circuits, which included touch-and-go landings[2], as part of his third solo flight. The student misaligned the downwind leg of the first circuit, tracking parallel to runway 35 left (35L) instead of the intended runway 31L (Figure 1). The effect was that the aircraft diverged from the intended circuit pattern by about 34°. A number of radio transmissions from the student pilot indicated that he was unable to locate a Cessna 152 aircraft, registered VH-CUL (CUL) that he was instructed to follow by the aerodrome controller – west (ADC W) at the commencement of the downwind leg.

Figure 1: UPY's first circuit from runway 31L[3] (actual circuit legs flown by the student pilot annotated in white)

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1 The 24-hour clock is used in this report to describe the local time of day, Eastern Standard Time (EST), as particular events occurred. Eastern Standard Time was Coordinated Universal Time (UTC) + 10 hours.

2 Practice landing in which the aeroplane touches the runway briefly, before the pilot applies power and lifts off.

3 The depicted circuit pattern appears long and thin. The shape has been extrapolated from the position of the runway in use and the location of the mid-air collision.

The ADC W, who in the period leading up to the midair collision was performing the dual functions of the aerodrome and surface movement controllers, identified the student pilot's wider than intended circuit track when UPY was about to turn onto the base leg from a very wide left downwind position, and provided instructions to the pilot to rejoin the normal circuit pattern on base for runway 31L. The ADC W had to repeat the clearance for a touch-and-go at the end of the student pilot's first circuit, as the student pilot did not respond to the first clearance instruction. The student pilot completed the touch-and-go on runway 31L.

Shortly after the student pilot's touch-and-go, the pilot of a following PA-28 aircraft, registered VH-NDR (NDR), requested an early left turn from the upwind leg of the circuit. That request was approved and placed NDR in front of UPY on the downwind leg of the circuit pattern.

The student pilot of UPY turned onto the downwind leg a second time, and received a sequencing instruction from the ADC W to follow a 'Cherokee on base correction the Cessna it is on base'. In fact, Cessna CUL was also in the circuit pattern in front of NDR. Shortly after, the ADC W corrected the sequencing instruction by advising the student to 'follow the Cherokee [NDR]'and the pilot conducted a second touch-and-go without the necessary clearance from the controller.

About 2 minutes later, the student pilot of UPY reported to the ADC W controller that he was on the downwind leg for his third circuit, and complied with instructions to follow the preceding aircraft, NDR.

When UPY was on the base leg of the circuit, the student pilot of CGT reported that he was 6 miles (11 km) north-west of the aerodrome, inbound at 1,500 ft above mean sea level (AMSL). The ADC W controller instructed the pilot of CGT to join the circuit on the downwind leg for runway 31L, and to report again at 3 miles (6 km) from the aerodrome.

The pilot of NDR was cleared for a touch-and-go and the student pilot of UPY continued the approach following NDR for a third touch-and-go. Shortly after, another aircraft, a Piper PA-28 registered VH-MGV (MGV) was cleared to line up on the runway for takeoff between NDR and UPY (Figure 2). The ADC W had to issue repeated take-off clearances to the pilot of MGV before the pilot acknowledged and complied with the clearance.

Figure 2: Circuit pattern shortly before UPY conducted a touch-and-go to commence a fourth circuit.

The student pilot of UPY completed the third touch-and-go, without receiving a clearance from the ADC W. On instruction from ADC W, Cessna 172 registered VH-EWZ (EWZ), conducted a go-around[4] from final behind UPY.

Interspersed with a number of radio conversations between the ADC W and two aircraft that were taxiing for departure, the pilot of CGT reported at 3 NM (6 km) from the aerodrome that he had entered the control zone[5] at 1,000 ft to join the circuit on left downwind for runway 31L (Figure 2). The ADC W controller acknowledged that report without providing relevant traffic information or sequencing instructions. The pilot of one of the taxiing aircraft was unfamiliar with the aerodrome's layout and procedures, and required extra taxi guidance from the controller. The other was preparing to conduct a flight under the instrument flight rules, which required more coordination between the pilot and controller.

During this period, the instructor in CGT told the student pilot in that aircraft to extend one stage of flap to slow the aircraft. That action was based on the instructor's understanding of the implied number of aircraft in the vicinity as a result of the amount of radio traffic as he tracked for downwind, and in response to a PA-28 aircraft (probably MGV) that was climbing on his left (Figure 3).

The ADC W continued controlling the traffic in the control zone and communicated with two other aircraft in the runway 31L circuit. That included the provision of a landing clearance to Cessna 172 aircraft, registered VH-EOZ (EOZ), and sequencing instructions to the pilot of EWZ, which was on downwind after its recent go-around.

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4 To abandon a landing and make a fresh approach.

5 Controlled airspace extending upwards from the Earth's surface to a specified upper limit.

Figure 3: Circuit pattern immediately before the collision

Almost immediately after, the ADC W noticed three aircraft in close proximity on late crosswind and advised the pilots in CGT that '...traffic is several in the circuit there, um some ahead of you some behind you' (Figure 3). CGT and UPY collided very shortly after that radio transmission.

Figure 4: Position of CGT and UPY shortly before the collision

Neither of the two pilots in CGT recalled hearing the ADC W controller's traffic alert.

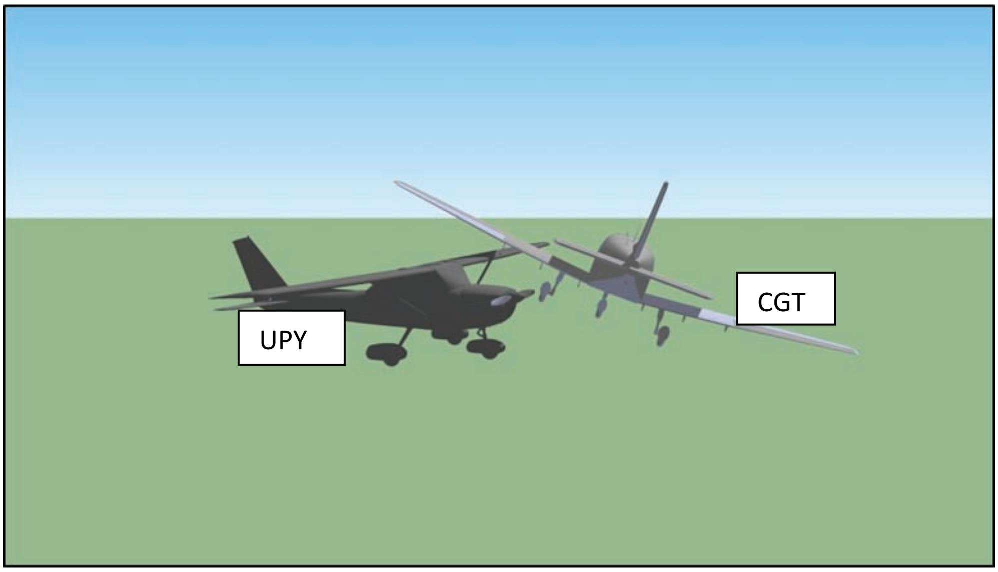
Recorded radar data indicated that, as CGT approached the circuit pattern, it was tracking slightly to the east of the location where the circuit traffic was turning from crosswind to downwind for the runway 31L circuit pattern.

The student pilot of CGT, who was seated in the aircraft's left seat and was flying the aircraft, reported seeing UPY very close and climbing on his left (Figure 4). The student pilot responded to what he felt was a collision course by turning hard right and descending in an effort to avoid a collision. The flight instructor in CGT did not see UPY prior to the collision.

There was no evidence of any manoeuvre by the student pilot of UPY in response to the proximity of CGT. A witness on the ground who was watching the aircraft and saw the collision stated that he did not see either aircraft manoeuvre to avoid the collision.

The two aircraft collided at 1237:52 (Figure 5).

Figure 5: Representation of the early collision sequence



A chronology of the key events leading up to the collision is at Appendix A.

Both aircraft were damaged during the impact sequence. Immediately after the collision, the instructor in CGT took control of the aircraft from the student pilot. The instructor then broadcast that he had just been involved in a midair collision and required an immediate landing.

The instructor in the right pilot's seat of MGV (Figure 3) reported being alerted to the collision by the broadcast from the instructor in CGT. He recalled that a few seconds later, he observed CGT close on his right and approaching on a collision course. The instructor took control of MGV and manoeuvred to avoid a collision by increasing the aircraft's angle of climb. The instructor stated that CGT flew close under MGV.

The occupants of CGT reported sighting an aircraft that could have been MGV passing from left to right in front of them, shortly before the collision. They did not see that aircraft after being involved in the collision with UPY.

The instructor in CGT reported using full power to regain control of the aircraft and to reduce the rate of descent. The instructor requested the controller to visually check the aircraft's landing gear, and then received a clearance to land on runway 35L. The instructor landed CGT without further damage or injury to the aircraft occupants.

The damage sustained by UPY rendered the aircraft uncontrollable, and the student pilot sustained fatal injuries in the subsequent impact with the ground.

Damage was sustained by a private residence from UPY's impact with terrain. A post-impact fire was fed by aviation fuel from the aircraft that drained into one of the residence's drains. The fire damaged a fence, parts of the residence and a vehicle that was parked in the driveway, and a neighbour's house (Figure 6).

Figure 6: Impact and fire damage to the private residence

Personnel information

Pilot information

Student pilot in UPY

The student pilot's qualifications and experience are listed in Table 1.

Table 1: Qualifications and experience

Pilot classification	Solo student
Licence held	Student Pilot Licence, issued June 2008
Medical certificate	Class 1 without restriction, issued 26 June 2008
Aeronautical experience	24 hours

The student pilot completed his first solo flight on 22 August 2008 and a second on 25 August 2008. The student pilot then conducted a check flight with a flight instructor later that day, in order to conduct his third solo flight. During that check flight, the student pilot experienced numerous sequence changes and had difficulty maintaining situational awareness, and in monitoring radio transmissions. As a result, he was not authorised to fly solo at that time because of the more complex circuit traffic conditions that would have affected the planned solo flight.

On 26 August 2008, a pre-solo check was truncated because strong crosswinds made the conditions unsuitable for an early-syllabus solo flight.

On 27 August 2008, the student pilot performed satisfactorily in a pre-solo check flight with a flying instructor. The instructor de-briefed the student on aspects of his flying technique on which to concentrate during the subsequent solo flight, which entailed consolidation solo circuits. The instructor did not provide any guidance to the student in the situation where the circuit activity changed during the student's solo flight. The collision happened during that flight.

It was not possible to ascertain if the student pilot was wearing sunglasses at the time of the collision.

Pilots of CGT

Student pilot

The student pilot's qualifications and experience are listed in Table 2.

Table 2: Qualifications and experience – student pilot

Pilot classification (Student)	Student under instruction
Licence held	Private Pilot (Aeroplane) Licence, issued April 2008
Medical certificate	Class 1 without restriction, issued 3 December 2007
Aeronautical experience	167 hours

Flying instructor

The flying instructor's qualifications and total aeronautical experience are listed in Table 3.

Table 3: Flying instructor's qualifications and experience

Pilot classification (Flight instructor)	Grade 3 Flying Instructor
Licence held	Commercial Pilot (Aeroplane) Licence, issued October 2007
Medical certificate	Class 1, issued 3 October 2007
Vision correction	Vision correction required and worn
Total experience	750 hours, including 450 hours instructional flying

Recent history

Nothing was found in the 3 days prior to the accident with the potential to have adversely influenced either pilot's performance in CGT.

The student pilot had not flown for over 2 months, as he had been undergoing theory classes.

The flying instructor stated that he was wearing sunglasses and corrected vision (contact lenses) at the time of the collision. The instructor also advised that the student was wearing sunglasses at the time of the collision.

Student pilot supervision

The handling pilots in UPY and CGT were both undergoing courses of flying instruction at the time of the collision. There was nothing in either pilot's flying training records to suggest an increased likelihood of either being involved in a midair collision.

The student pilot of CGT, and other pilots from the same flying school with comparable levels of experience as the pilot of UPY, demonstrated a good understanding of the published operating procedures for operations in the Moorabbin General Aviation Aerodrome Procedures (GAAP) control zone.

Air traffic controller information

There were three air traffic controllers in the control tower at the time of the occurrence. Those positions included ADC W, Aerodrome Control East (ADC E) and Surface Movement Control/Coordination (SMC).

The SMC controller had just returned from a scheduled rest break, but had not yet returned to duty at the console. During the SMC's rest break, ADC W was responsible for the SMC and ADC W positions.

The ADC W controller met the recency, familiarisation and endorsement requirements for that position. He held a current Civil Aviation Medical Certificate (Class 3) that was issued by the Civil Aviation Safety Authority, and was reported to be well rested prior to the commencement of the shift.

Air traffic controllers are trained and regularly assessed in their ability to maintain an understanding of the complete traffic pattern in their area of responsibility, and to provide adequate relevant traffic information and instructions to aircraft in that area. The ADC W controller satisfactorily completed a routine operational assessment of his capacity to operate as a controller 2 months prior to the occurrence.

Aircraft information

Information on both aircraft that were involved in the collision is at Table 4.

Table 4: Aircraft information

Registration	VH-UPY	VH-CGT
Type	Cessna A150M	PA-28-161 Warrior
Operational category	Aerobatic	Utility
Engine	Teledyne Continental O-200-A	Textron Lycoming O-320
Propeller	Fixed pitch	Fixed pitch
Year of manufacture	1976	1977
Owned by operator since	2005	2005
Recorded flight time	10,923 hours	12,714 hours

Both aircraft were operated by the same flight-training organisation. The paint scheme on CGT was white, with dark blue and bronze fuselage stripes and a darker paint scheme on the fin. The paint scheme on UPY was also white, with a similar paint scheme on the fin and thinner paint stripes on the side of the fuselage.

A review of the aircraft maintenance documentation indicated that there was no unserviceability on either UPY or CGT prior to the midair collision and that all applicable maintenance had been conducted on both aircraft.

Meteorological information

At the time of the occurrence, the automatic terminal information service (ATIS)[6] for the aerodrome indicated that the wind was from the west at 10 kts or less, and that there were three to four oktas[7] of cloud at a height of 3,000 ft.

Visibility was greater than 10 km; however, there was a band of low cloud and drizzle beyond the GAAP control zone in an arc from the west to the south-east of the aerodrome. The collision happened to the north-west of the aerodrome.

The elevation of the sun was 41° above the horizon and its position was just west of north at the time of the accident.

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6 A continuous broadcast of recorded non-control information in selected high-activity areas to improve controller effectiveness and relieve congestion by automating the repetitive transmission of routine information.

7 Cloud amounts are reported in oktas. An okta is a unit of sky area equal to one-eighth of total sky visible to the celestial horizon. Few = 1 to 2 oktas, scattered = 3 to 4 oktas, broken = 5 to 7 oktas and overcast = 8 oktas.

Communications

A number of aircraft within the Moorabbin airspace at the time of the accident were being flown by pilots for whom English was not their first language. An examination of the recorded radio communications at Moorabbin indicated no communication difficulties that could be attributed to the use and/or comprehension of the English language.

Aerodrome information

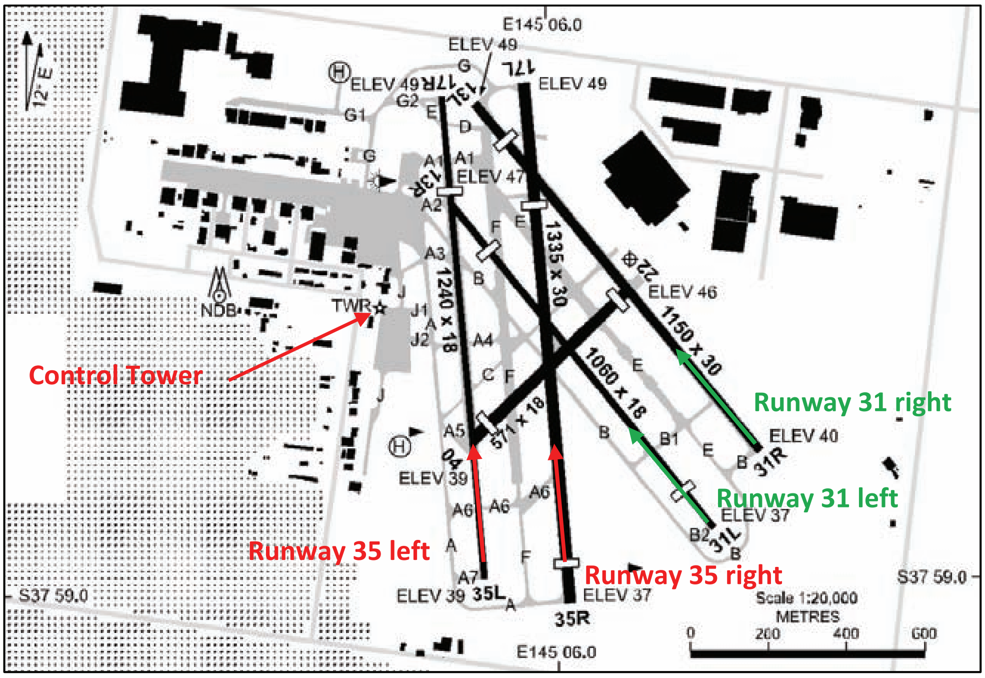
Aerodrome facilities

Moorabbin Aerodrome was located in the south-eastern suburbs of Melbourne. Traffic normally operated using two parallel runways that were oriented south-to-north (runway 17/35) and south-east-to-north-west (runway 13/31).

Separation between aircraft operating from parallel runways was established by the use of contra-rotating circuit patterns for aircraft operating from each runway. The control tower was located to the west of the runways. Circuit operations were normally conducted from the eastern runway (runway 35R/17L or 31R/13L). Arrivals and departures to the west were conducted from the western runway (runway 35L/17R or 31L/13R). Arrivals and departures to the east were conducted from the eastern runway (runway 35R/17L or 31R/13L) (Figure 7).

Runway 17/35 was not available for use on the day of the occurrence as a crane was operating near the threshold of the 17 runways. The crane's location prevented the use of runway 17/35.

Figure 7: Map of Moorabbin aerodrome



Air traffic control

At the time of the occurrence, the ADC W was responsible for air traffic operating to or from runway 31L, all surface movements and for coordination with other control functions. To fulfil those functions, ADC W was using two radio frequencies, one for controlling air traffic and the other for aircraft operating on the ground. The radio frequencies were combined, enabling the ADC W to use a single microphone and speaker, with both frequencies retransmitted (radio transmissions on one frequency were retransmitted on the other frequency).

The radio transmissions were almost continuous in the 45 seconds before UPY's second touch-and-go, which was carried out by the pilot without clearance from the ADC W. The controller had been controlling up to eight different aircraft, including two aircraft that were inbound from the south and were cleared to land behind UPY's touch-and-go.

The action by ADC W to direct another aircraft (EOZ), which was on early downwind to follow UPY as it was turning onto final for a third touch-and-go, did not mention two other aircraft that were on downwind between UPY and EOZ.

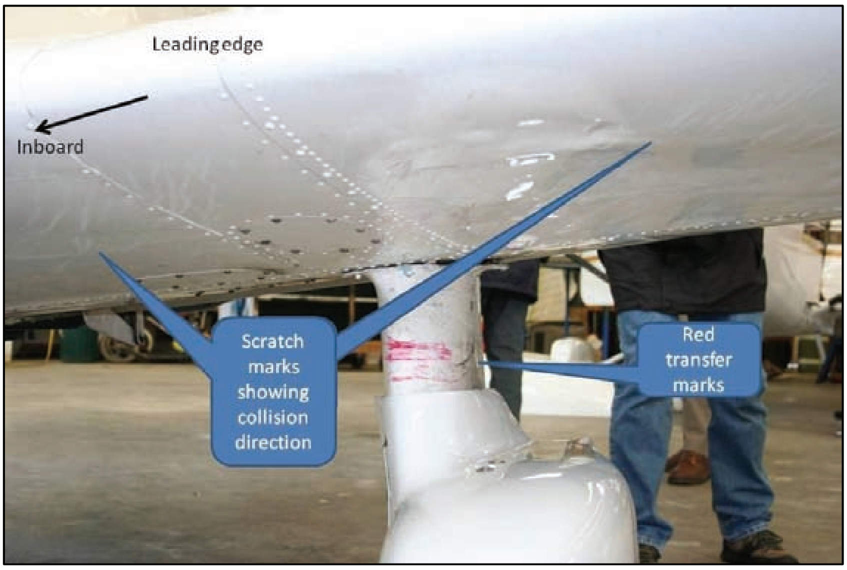
When the pilot of CGT reported that he was 3 NM (6 km) north-west of Moorabbin aerodrome, he received an acknowledgement from the controller but no instructions or traffic information. The collision with UPY occurred about 1 minute later.

Wreckage and impact information

Midair collision

The damage to UPY that was attributed to the midair collision was consistent with the nature of the impact as described in witness reports. That was, the aircraft's left wing collided with the lower inboard section of the left wing of CGT near the left main landing gear (Figure 8). The fuel drain to CGT's left fuel tank appeared to have broken off during the collision, as both pilots in that aircraft reported the development of a fuel leak from that area. The fuel drain was subsequently unable to be located.

Figure 8: Scratches and wiring insulation transfer marks on CGT's left wing and landing gear

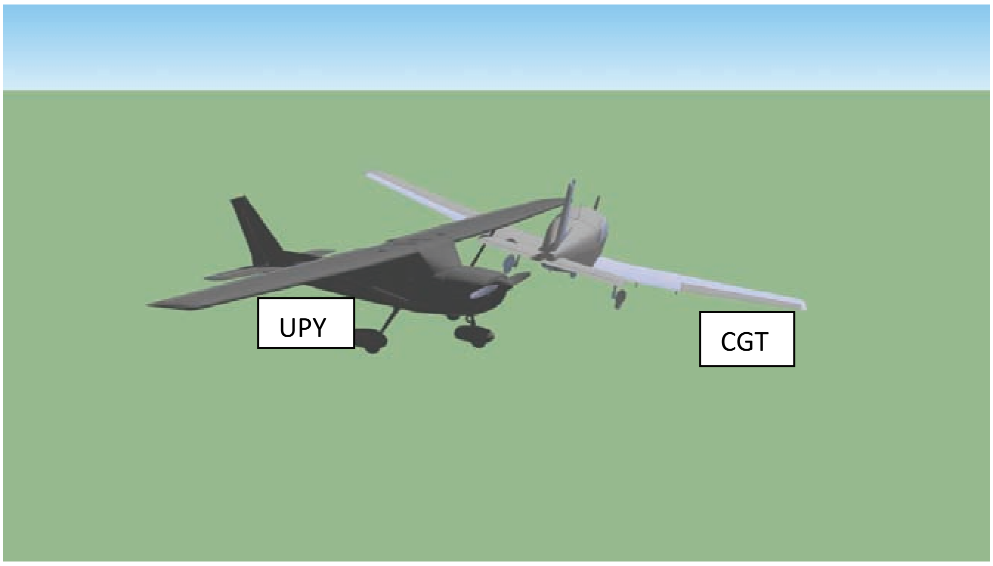


The red paint transfer on CGT's left landing gear and other surfaces was consistent with contact with the red Teflon lining of the insulated electrical wiring that was connected to UPY's wingtip navigation lights (Figure 9).

Figure 9 Damaged red electrical insulation from UPY's left wing

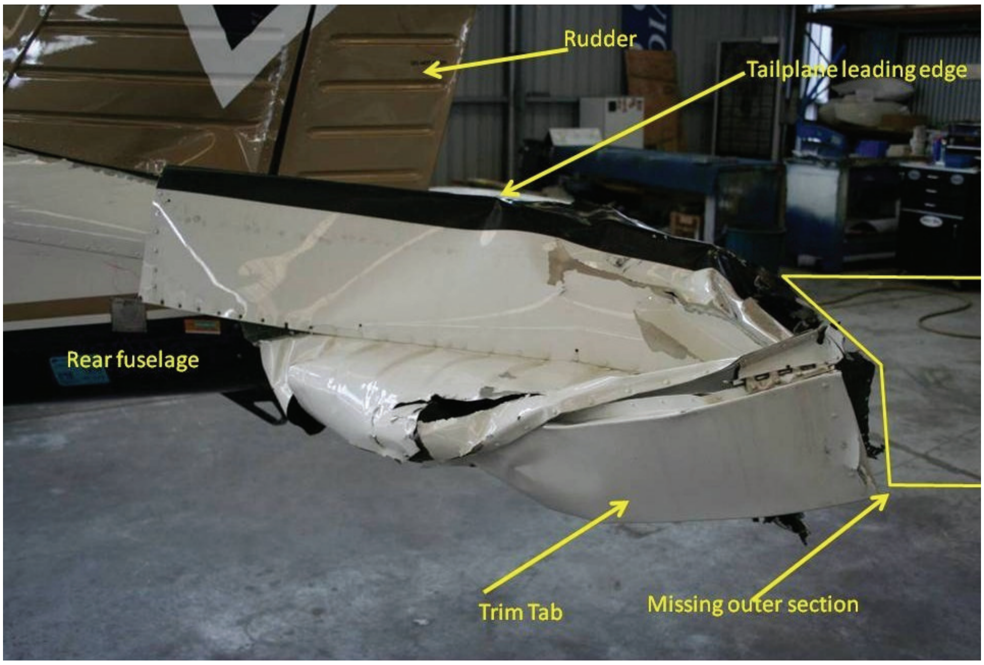
The left wing of UPY also struck the left wing and flap, and the left rear fuselage, of CGT. During the subsequent impact, the outer section of CGT's tailplane detached and became entangled in the outer-left wing strut mounting on UPY (Figure 10). That section of tailplane was found at the accident site with the wreckage of UPY.

Figure 10: Representation of the latter stages of the impact sequence



The remainder of CGT's left tailplane was folded upwards and rearwards by the force of the impact (Figure 11). There was also impact damage to the left side of the aircraft's fin and rudder.

Figure 11: Left tailplane damage to CGT



The outer section of the UPY's left wing was severely damaged, forcing the leading edge and wing structure rearward against the left aileron and compromising the aileron control system. The aircraft was reported to have descended almost vertically after the collision (Figure 12), and was seen by witnesses to roll a minimum of three times before impacting the ground.

The impact with the ground ruptured UPY's wing fuel tanks and a post-impact, fuel-fed fire consumed the aircraft's fuselage, the inner section of the right wing, the mid-rear section of the left wing, the right tailplane and the fin and rudder. The cockpit and fuselage structures were destroyed by impact forces and the post-impact fire.

Figures 12: Witness images of the damage to UPY

Wreckage information

Consistent with the witness reports of the almost vertical descent of UPY after the midair collision, the aircraft impacted terrain at high speed in a steep, nose-down attitude. The aircraft was destroyed by the impact and post-impact, aviation fuel-fed fire (see Figures 6, 13 and 14). The roof of the double garage and front of a private residence was damaged before the aircraft came to rest to the side of the adjoining house.

The aircraft's propeller impacted a courtyard at the rear of the house, about 30 cm from the edge of the garage floor. The engine, the lower part of the engine nacelle and the engine cowling were located slightly further away from the house, immediately beyond the propeller (Figure 14). The remains of the cockpit floor, cabin and one seat were found immediately behind the engine, the second seat was to the right of the engine.

Parts of the aircraft's instrumentation were found in the vicinity of the cockpit floor and engine. No useful information could be obtained from those instruments because of the degree of damage.

Figure 13: Aircraft wreckage

There was a substantial overstress failure of the aircraft's primary structures as a result of ground impact, resulting in compression and separation of the left wing's upper skin, outboard of the flaps. The spars, ribs, frames and bulkheads of both wings were twisted and bent as a result of the impact.

The remains of the left wing, except the aileron, were located with the majority of the wreckage. The left aileron was found on the roof of the house next door to the accident site. The right wing was located on the roof of the double garage with the outer section of the wing, including the aileron, hanging over the fence of the adjacent property. Substantial leading edge compression was observed on both wings.

Most of the aircraft's tail was destroyed by the post-impact fire, except the left tailplane, elevator, right elevator trim tab, the lower section of rudder and the lower rear spar of the fin.

Pieces of perspex were found over an area measuring 100 m from the accident site. The outboard section of CGT's left tailplane was found in the vicinity of UPY's left wing (Figure 14).

Figure 14: UPY's left wing and a section of CGT's left tailplane

Medical and pathological information

The pilot's post-mortem report indicated areas of up to 80% occlusion of two coronary arteries. The examining pathologist stated that:

> Given the degree of coronary artery narrowing, consideration should be given to the possibility that this individual's ability to control a vehicle such as an aircraft may have become impaired at some stage.

and that:

> Individuals with considerable coronary artery narrowing may be at increased risk of sudden arrhythmic myocardial events and it is possible that such events might also be precipitated by physical and or psychological stressors.

Organisational and management information

Rules of the air

In respect of the right of way in the case of converging aircraft, Civil Aviation Regulation (CAR) 162(1) stated:

> When 2 aircraft are on converging headings at approximately the same height, the aircraft that has the other on its right shall give way,...

In addition, CAR 161(2) stated that, in respect of the right of way:

> The pilot in command of an aircraft that has the right of way must maintain its heading and speed, but nothing in the rules in this Division shall relieve the pilot in command of an aircraft from the responsibility of taking such action as will best avert a collision.

The responsibility of flight crew to see-and-avoid another aircraft was specified in CAR 163A as follows:

> When weather conditions permit, the flight crew of an aircraft must, regardless of whether an operation is conducted under the Instrument Flight Rules or the Visual Flight Rules, maintain vigilance so as to see, and avoid, other aircraft.

General Aviation Aerodrome Procedures

The Australian Aeronautical Information Publication Book (AIP) was the primary document for the promulgation of long- and short-term reference information for application to operations in Australian airspace. Promulgated by Airservices Australia (Airservices), the AIP stated that General Aviation Aerodrome Procedures (GAAP) were designed to cater for high density air traffic operations. Those operations were possible by day and night in visual meteorological conditions (VMC), within a GAAP control zone (CTR). The procedures emphasised the pilot's responsibility to see and avoid other aircraft, while controllers provided relevant traffic information to pilots.

Pilot procedures

In VMC, pilots in command were primarily responsible for ensuring separation from other aircraft and were required to:

- Sight and maintain separation from other aircraft whilst operating in the GAAP CTR;
- Comply with ATC instructions while ensuring that separation is maintained with other aircraft;
- Immediately advise ATC if unable to comply with a control instruction;
- Advise ATC if unable to sight, or if sight lost of, other aircraft notified as traffic.
- For a VFR flight, arrange own wake turbulence separation when operating in the GAAP CTR, except when separation is being applied by ATC for aircraft during take-off and landing.

Pilots were expected to manoeuvre as required to maintain their own separation from other traffic and to maintain their aircraft's position in the traffic sequence. Pilots therefore had to maintain a good awareness of other traffic in the vicinity to enable them to fulfil those functions.

Air traffic control procedures

The GAAP required air traffic control (ATC) to:

- apply runway separation standards

- issue instructions and/or traffic information to regulate traffic
- provide relevant traffic information inside the control zone
- maintain surveillance of aircraft activity within the CTR and on the aerodrome, when practicable.

The Manual of Air Traffic Services (MATS) set the requirements for the provision of air traffic services. MATS prescribed the following situations when traffic information was to be provided by controllers in GAAP control zones:

> the pilot of one aircraft was required to give way to, follow, or otherwise adjust the aircraft's flight path to that flown by another aircraft,
>
> the relative positions of aircraft cannot be established, and a collision or near miss may be likely unless one or both aircraft adjust their respective flight paths - in that case the alerting service will be prefixed with the cautionary word ALERT.

Controllers used either a clearance, which was an:

> authorisation for [the pilot of an] aircraft to proceed under conditions specified by an Air Traffic Control unit.

or an instruction, which was a:

> directive issued by Air Traffic Control for the purpose of requiring a pilot to take a specific action.

A pilot required a clearance before entering a GAAP control zone, using an active runway or conducting activities that were contrary to the published procedures. An instruction for circuit entry or transit was considered as a clearance.

Combination of GAAP radio frequencies

Most GAAP aerodromes normally operated using two parallel runways. Each runway operated with opposing circuit directions to ensure the separation of circuit traffic.

Normally GAAP control towers operated with two aerodrome controllers (ADCs) who communicated with pilots of aircraft operating from each parallel runway on separate radio frequencies. At Moorabbin, those frequencies were allocated to the ADC - east (ADC E) and ADC W positions and a third, surface movement control (SMC) frequency was used to communicate with pilots of aircraft manoeuvring on the ground.

At times, it was necessary to combine two of the frequencies at GAAP aerodromes. Options included the combination of two airborne frequencies, or the combination of the SMC frequency with one of the ADC frequencies.

The normal practice at Moorabbin was to combine the SMC frequency with one of the ADC frequencies.

Separation assurance

Where controllers were responsible for applying separation standards, the MATS described the need for separation assurance in both the strategic and tactical environments. The concept of 'strategic separation assurance' was described as:

> ...the designing of airspace, air routes, air traffic management plans and air traffic control practices, to reduce the likelihood that aircraft will come into conflict, particularly where traffic frequency congestion or system performance, amongst other considerations, may impair control actions.

There were no separation standards for VFR aircraft at GAAP aerodromes beyond those affecting active runways. That aside, separation assurance, in a tactical sense, was not applicable to GAAP aerodromes.

Strategic separation assurance principles had been considered when developing non-GAAP control zones. Those principles had limited applicability in GAAP aerodrome as there was no separation standards applied between airborne aircraft.

Vertical separation assurance

There were six GAAP aerodromes in Australia, including: Archerfield, Queensland; Bankstown and Camden, New South Wales; Jandakot, Western Australia; Moorabbin, Victoria; and at Parafield, South Australia. Each had specific procedures for aircraft operating in the vicinity of the respective aerodrome.

The strategic design intent at most GAAP aerodromes meant that arriving aircraft were vertically separated from circuit and departing aircraft until they reached a specific position or received a joining instruction. If a pilot received circuit joining instructions from ATC, then the pilot would also be informed of any relevant traffic, and how the aircraft was to be positioned in relation to that traffic.

Most GAAP procedures required departing aircraft to leave the control zone at the published circuit altitude, and for arriving aircraft to normally enter the control zone at 500 ft above the circuit altitude.

Unlike all of the other GAAP aerodromes in Australia, at Moorabbin the circuit entry altitude was the same as the circuit altitude, while departing aircraft normally left the control zone while climbing to at least 500 ft above the circuit altitude. The effect was that at Moorabbin, arriving aircraft did not have a designed strategic vertical separation from aircraft in the circuit.

In contrast, the vertical separation assurance requirements were strengthened further under the Camden Aerodrome GAAP procedures, where inbound aircraft were required to remain at the inbound altitude until pilots had received a sequencing instruction from ATC. Those instructions described the relative positions of aircraft to follow, if any were present.

Lateral separation

Some GAAP aerodromes, including Parafield, Archerfield, Bankstown and Jandakot had lateral separation assurance designed into the respective aerodrome's GAAP airspace procedures, with different routes specified for inbound and outbound aircraft. Although inbound and outbound routes were not specified at Camden, the Camden procedures required all departing aircraft to track clear of inbound reporting points.

There were published flight procedures for some inbound and outbound routes at Moorabbin, but not for the arrival route used by CGT. The pilots of arriving aircraft at Moorabbin normally received circuit joining instructions when first contacting the aerodrome controller. At that time, affected aircraft could be some distance from the circuit pattern, and the instructions could be updated by the controller as the aircraft approached the circuit.

The traffic flow design at GAAP aerodromes, including at Moorabbin, had locations where different traffic flows converged in the same airspace. Those locations were known and referred to by air traffic controllers as 'hot spots', and a controller's location-specific endorsement to operate as a controller at Moorabbin included the requirement that the hot spots were managed adequately. Controllers stated that those 'hot spots' had an increased potential for midair collision.

The collision between UPY and CGT happened at a known hot spot.

Review of Safety

Airservices was required under the Civil Aviation Safety Regulations 1998 (CASR) Part 172.145 to have and review a safety management system (SMS). That system was required to incorporate processes for internal safety reviews, and for the identification, assessment, control and mitigation of existing and potential safety hazards in service provision.

Airservices had an SMS in place at the time of the collision that applied to the provision of ATS and included operations at Moorabbin Aerodrome.

An Airservices internal GAAP review, dated 8 December 2006, recommended that:

> [Airservices] Safety Management Group to conduct a review and comparison of any Key Performance Indicators (KPI) affecting GAAP to ensure an appropriate balance is being maintained between financial, operational and safety decision making across the organisation.

The action arising from this recommendation was assigned to the Airservices Safety Management Group.

On 9 September 2008, the action was 'closed', as the action was reassigned to the Airservices Air Traffic Control Group. There was no evidence to indicate that the action arising from this recommendation had been addressed at the time of the accident.

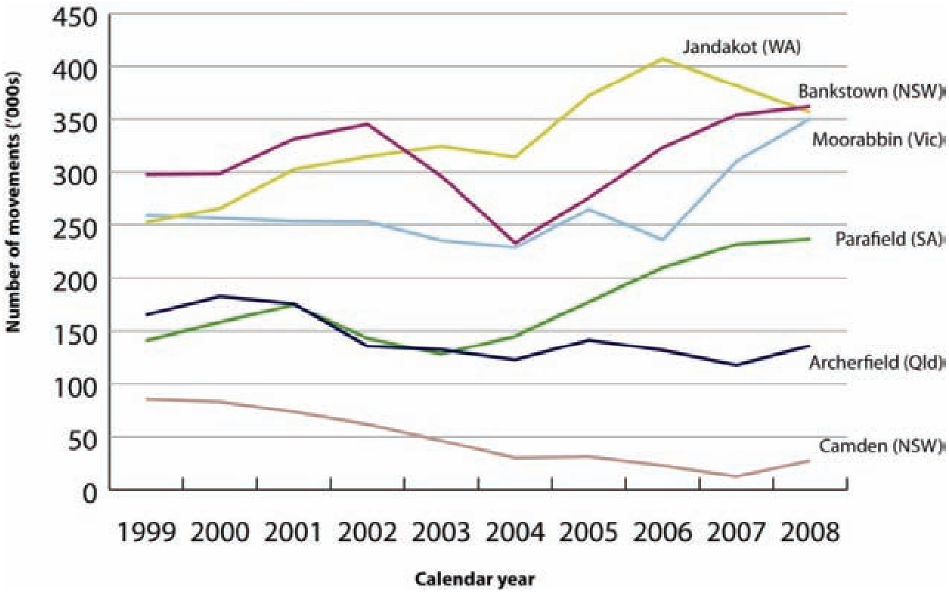
Additional information

Operations at Moorabbin

Numbers of aircraft movements

Airservices recorded monthly traffic movement data for Moorabbin Aerodrome, and published the data on its website. In the 2 years before the collision, Moorabbin experienced a 40% increase in aircraft movements, greater than at any other GAAP aerodrome (Figure 15), although there had also been major increases at other GAAP aerodromes. The Moorabbin controllers stated that their workload reached a peak in April 2008.

Figure 15: Aircraft movements at GAAP aerodromes, 1999 to 2008[8]



The Moorabbin tower staffing levels had not been changed during that period.

In November 2007, an Airservices check and standardisation supervisor recommended that, at Moorabbin:

> Local management to re-assess current and projected staffing scenarios. Develop and action a plan that will ensure that staffing is adequate to safely and efficiently manage current and projected demand.

That recommendation was not converted into an Airservices System Action Improvement Report (SAIR), which would have tracked any progress on that recommendation. The tower manager at Moorabbin was not aware of any action taken in response to that recommendation.

Moorabbin controllers stated that a period of higher traffic movements occurred 4 months before the accident. One controller reported that, during that period, there was a 150% increase in the number of running sheets for the normally-used training circuit pattern, and a 300% increase in the number of running sheets for the other circuit pattern that was used by arriving and departing aircraft.

It was reported that, when the circuit pattern that was primarily used for circuits became full, any traffic overflow was transferred to the other runway. Controllers stated that this led to a varying and often increasing workload in specific areas of the Moorabbin control zone. No procedure was identified to manage an uneven distribution of workload.

The midair collision occurred in the circuit that was being used for traffic overflow.

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8 See ATSB publication 'Australian Aviation Safety in Review: 1998 to 2007'

Variations in traffic complexity and density

Air traffic controllers at Moorabbin advised that the potential for a midair collision in GAAP airspace was related to controller workload, which was affected by the complexity and density of traffic within the airspace.

Traffic complexity was described as those factors that could affect the variability of traffic within the control zone, including:

- differing aircraft operating speeds
- differing flightpaths
- differing operating requirements
- varying pilot capabilities.

Management of controller workload

Different controllers described different workload management strategies in response to busy or complex air traffic situations. One controller reported prioritising any radio transmissions. Another would not deny an arriving aircraft a clearance to enter the GAAP control zone, accepting the increased controller workload to reduce the separation risk affecting aircraft flying in uncontrolled airspace in close proximity to, or just outside the control zone. Yet another controller would seek help as and when required, and require inbound aircraft to remain outside the control zone in a holding pattern until able to be processed.

In the period leading up to the midair collision, the ADC W controller was operating the combined ADC W and SMC frequencies. The ADC W stated that the traffic had been busy, but not such that the controller was at full capacity. The ADC W commented that there had been an increase in traffic complexity because of the number of inbound, departing, taxiing and circuiting aircraft.

Despite the increased workload, the ADC W did not seek operational assistance from the controller who had recently returned from a rest break. That was because the ADC W believed that the returning controller would not have had a full understanding of the traffic pattern and would not have been able to provide immediate assistance. Instead, the returning controller was asked to take over some operational tasks that were not directly relevant to controlling circuit traffic, allowing the ADC W to apply more attention to managing the aircraft operating in the ADC W's area of responsibility.

Management of change

Moorabbin aerodrome's air traffic operating systems had evolved since GAAP was implemented in 1980 to take account of changes in the traffic density and complexity, technology changes and changes in operator expectations. In response, the air traffic management procedures at Moorabbin were incrementally modified to manage the changing operating environment.

An Airservices review in December 2006 found that the nature and type of operations at GAAP aerodromes might no longer have been consistent with the original GAAP airspace design intent. There was no evidence of the use of the original design intent as a basis for measuring the ongoing safety performance of GAAP aerodromes.

Aircraft conspicuity

The term 'conspicuity' refers to the visual salience or distinctiveness of an object. It is associated with the physical properties of the object and its background, rather than the observer's visual abilities. The salience of an object can be affected by the contrast of that object against the predominant background and by any perception of movement against that background.

The Australian Transport Safety Bureau (ATSB) research report *Limitations of the See-and-Avoid Principle*[9] found that an aircraft's visibility was influenced more by the contrast between the aircraft and its background than from the colour of the aircraft itself. The report found that:

> A dark aircraft will be seen best against a light background, such as bright sky, while a light coloured aircraft will be most conspicuous against a dull background such as a forest.

As viewed from UPY, CGT would have been visible against a background near or just above the horizon. In contrast, when viewed from CGT, UPY would have been visible at a level near or just below the horizon. In that context, neither aircraft's colour scheme was consistent with increased conspicuity in terms of the contrast between the aircraft and its background.

A photograph of UPY immediately after the midair collision showed the aircraft in bright sunlight with sharp shadows on the surface of the airframe (Figure 12). That reasonably high level of background luminance was consistent with an overall increased level of contrast between the aircraft and its background. In respect of the utility of aircraft lighting in increasing the likelihood of sighting an aircraft, the ATSB research report *Limitations of the See-and-Avoid Principle* states that:

> The visibility of a light largely depends on the luminance of the background and typical daylight illumination is generally sufficient to overwhelm even powerful strobes.

The aircraft operator's standard procedures required aircraft rotating beacons to be switched ON prior to flight. There was no evidence to suggest that either aircraft's rotating beacons were not operating in this instance.

Cockpit visibility and relative aircraft movement

Two aircraft that are on a collision path and do not change their speed or direction will not move in each pilot's field of view. A pilot is much more likely to sight another aircraft in the vicinity if the aircraft is moving across the pilot's field of view.

The relative positions of the converging aircraft was estimated based on the standard performance of the aircraft types, the normal track of an aircraft on the crosswind leg of the circuit, the recorded radar track of CGT and the observed wind conditions. On that basis, it was concluded that the two aircraft were probably approaching each other at a relative velocity of about 110 to 120 kts at an angle of about 115° between the respective flight paths (Figure 4).

The application of cockpit visibility diagrams to the examination of midair collisions was examined in ATSB investigation AO-2007-065 (available at

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9 Available at http://www.atsb.gov.au/media/32918/limit_see_avoid.pdf

www.atsb.gov.au). The cockpit visibility from the high-wing UPY and low-wing CGT is examined in the following discussion.

The view of CGT from UPY

The position of CGT as seen from UPY would have remained stationary in the windscreen, about 43° to the right of the centreline of UPY. The position of the sun would have been well above and to the right of CGT as seen from UPY.

It is likely that CGT would have been low in the windscreen of UPY, as UPY would have been flying with a high nose attitude as the aircraft climbed. The likely position of CGT in the field of view of the pilot in UPY is represented by the red cross in Figure 16.

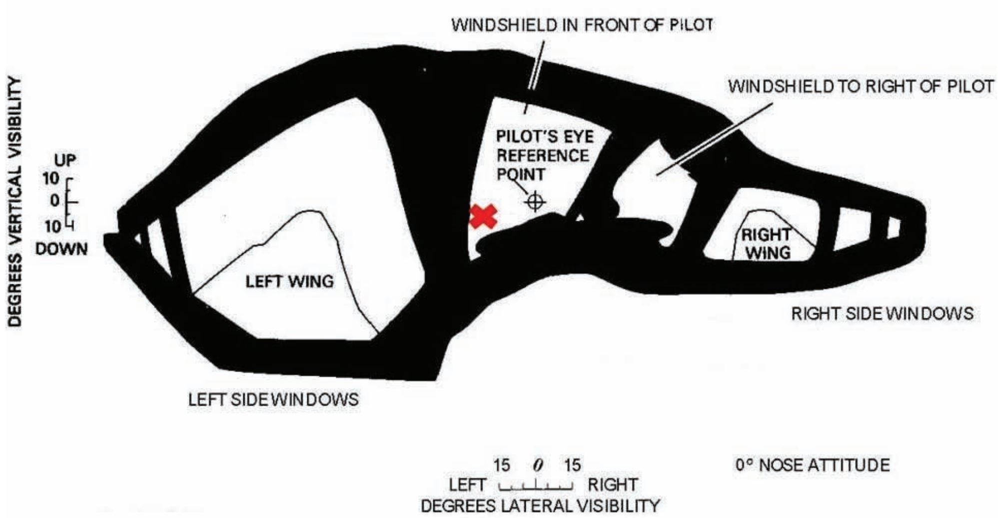
Figure 16: UPY cockpit visibility diagram. The red cross indicates the likely position of CGT as the aircraft closed on each other

The view of UPY from CGT

The view of UPY from CGT would also have been stationary in the windscreen of CGT, about 24° to the left of the centreline of CGT. The position of the sun would have been behind CGT, and would not have been in the pilots' field of view.

It is likely that the view of UPY to the student pilot would have been low or at the same height in the windscreen of CGT, as UPY was either still climbing, or at the same height as CGT (Figure 17).

Figure 17: CGT cockpit visibility diagram. The red cross indicates the likely position of UPY as the aircraft closed on each other



The instructor was seated in the front right seat in CGT, where the view of UPY may have been obscured by the magnetic compass, which was mounted on the central windscreen pillar.

The westerly wind at the time of the collision meant that CGT's heading was likely further to the right when compared with the ground track indicated on the radar plot. In that case, the drift angle may have moved UPY's position 5° to10° further to the left in the pilot's field of view.

Situational awareness

In simple terms, situational awareness can be described as knowing what is going on around you.[10] More formally, situational awareness has been defined as:[11]

> ...the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future.

Maintaining a high level of situational awareness is essential to flight safety. In practice, that means that a pilot must continuously monitor his or her environment, and be alert for any significant changes and the possible effect they might have on flight safety.

Developing and maintaining situational awareness involves three aspects:

- perception - gathering relevant information
- integration - interpreting the information
- projection - anticipating future states.

For example, a pilot may receive information from an instrument scan, from looking out for conflicting traffic, from radio communications, and from other

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10 Endsley, M., & Garland, D. (2000). *Situation Awareness: Analysis and Measurement*. Mahwah, NJ: LEA.

11 Endsley, M. (1995). Towards a theory of situation awareness. *Human Factors*, 37, 32-64.

sources. He/she must then process that information to make sense of it, and then plan and prioritise their subsequent actions in order to maintain situational awareness.

Factors that can influence situational awareness

Situational awareness is very context specific, relating to a particular task and operating environment. The maintenance of situational awareness is dependent on a pilot's attention and working memory. Therefore, factors such as workload, fatigue, stress, and distraction can have a detrimental effect on situational awareness. Good task management is essential to minimise the effect of workload or distraction, and fitness for duty is essential to minimise the possible effects of fatigue or stress on pilot performance.

A pilot's level of experience can also affect their ability to maintain situational awareness. More experienced pilots are better able to recognise what information it is important to seek or to attend to; to integrate various pieces of information to understand the 'big picture'; and to anticipate likely outcomes and hence stay 'ahead of the aircraft'.[12] In addition, more experienced pilots need to devote less conscious effort to the primary flight tasks, freeing up mental resources that can be used to maintain situational awareness.

See-and-avoid

To see and then avoid another aircraft requires a pilot to perform a number of tasks. The 'see' component involves the following steps:

- **Search:** The pilot looks outside the aircraft, and searches the available visual field. That search may or may not be in response to traffic information, or can be based on previous information about another aircraft's position.
- **Detection:** The pilot may detect possible conflicting aircraft or objects of interest.
- **Identification:** If an object is detected, it is then examined to determine if it is an aircraft or other potential collision threat.

The 'avoid' component involves the following steps:

- **Threat assessment:** If an object is identified as an aircraft, its altitude, heading and speed must be assessed to determine whether or not it is a collision threat.
- **Development of an avoidance plan:** If the aircraft is assessed as a collision threat, a decision must be made as to what type of response is appropriate.
- **Avoidance response:** The pilot must initiate the necessary control movements to take evasive action. There will also be a time period required for the aircraft to respond to the pilot's input and move away from a collision path.

For each of these six steps, there are many factors that can limit the timeliness and effectiveness of pilot performance. In some instances it may take up to 12.5 seconds to complete all of the above steps. Detailed information on these limitations is

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12 Endsley, M., Garland, D., Shook, R., Coello, J., & Bandiero, M. (2000). *Situation Awareness in General Aviation Pilots*. NASA-Ames Research Center Contract NAS2-99073 Report SATECH-00-01. Marietta, GA: SA Technologies.

provided in a number of sources, including the ATSB 2004 research report *Limitations of the See-and-Avoid Principle*.[9]

The factors that can affect the likelihood of a pilot seeing another conflicting aircraft in sufficient time to make the necessary control movements and allow the aircraft to respond and avoid that aircraft include:

- a foreknowledge of the existence and relative location of the other aircraft (alerted see-and-avoid)
- the size, conspicuity and speed of the other aircraft
- the different types and operational characteristics of aircraft operating within a defined airspace, and the number of aircraft in that airspace
- cockpit visibility, blind spots and background contrast
- fatigue and stress.

ANALYSIS

During normal operations in the Moorabbin General Aviation Aerodrome Procedures (GAAP) control zone, a Cessna A150M aircraft, registered VH-UPY (UPY), and a Piper PA-28-161 aircraft, registered VH-CGT (CGT) collided in midair. No technical factors were identified in either aircraft that might have contributed to the collision, the ambient conditions were benign, and the position of the sun was not a factor.

Although the student pilot of UPY was found to have had a partial occlusion of the coronary artery, there was no indication of a cardiac event immediately before the collision. The fitness of the pilots in CGT was not a factor.

In accordance with *Civil Aviation Regulations (1988)*, CGT had the right of way over UPY leading up to the collision. The inaction by the student pilot of UPY suggested that CGT was not sighted prior to the collision. The avoiding action by the student pilot in CGT was, although unsuccessful in the small time remaining between the first sighting and the collision, consistent with the requirement to see-and-avoid other aircraft.

While it was a pilot responsibility to sight and maintain separation from other aircraft whilst operating in a GAAP control zone, this analysis will examine a number of factors that affected the pilots' appreciation of their converging flightpaths in sufficient time to avoid the collision.

The student pilot of UPY - situational awareness

The student pilot's low experience meant that the workload associated with the operation of the aircraft and skills consolidation during the flight was inherently high. In combination with the emphasis placed by the student's flying instructor on improving flying technique during the solo flight, it could be expected that just operating the aircraft would have consumed a large amount of the student's attention.

In addition to the high workload associated with early solo flight, circuit operations require pilots to visually search for traffic and to monitor radio transmissions in order to sequence themselves properly in the circuit and to maintain situational awareness. The pilot would have heard the radio transmissions between the controller and the other aircraft operating in the same circuit pattern. While the comprehension and interpretation of the content of those radio transmissions would have enhanced the pilot's situational awareness, that activity would also have increased the pilot's workload.

In that context, any action by the aerodrome controller – west (ADC W) to pass traffic on the arriving CGT could have added greatly to the student's situational awareness. In addition, a foreknowledge of the existence and relative location of another aircraft has been shown to affect the likelihood of a pilot seeing that aircraft in sufficient time to initiate avoidance action. Any action to alert the student of the position of CGT had the potential to assist the student to see CGT in sufficient time to make the necessary control movements to avoid the collision.

The difficulty experienced by the student pilot in maintaining situational awareness and in monitoring radio transmissions in an earlier solo flight suggested that, should the student's workload increase markedly during the solo, his situational awareness would be adversely affected. The incorrect downwind track by the student on the first circuit, acceptance of a confusing air traffic control (ATC) instruction, and conduct of a number of touch-and-goes without ATC clearance would suggest that was the case. That could explain the lack of any evidence to indicate that the pilot of UPY was aware of CGT as the aircraft converged.

The lack of any direction from the student's flying instructor about actions to be taken when there is elevated circuit traffic increased the risk that the student might become overloaded and lose situational awareness.

Pilots' lack of awareness of each other in sufficient time to avoid the collision

The provision by ADC W of circuit joining instructions to the pilots of CGT, and acknowledgement of the student pilot's report at 3 NM (6 km) from the aerodrome, both without any directed traffic information being provided by the controller, constrained the pilots to compiling their 'picture' of the circuit traffic by listening to the radio transmission between ATC and that traffic. The action by the instructor in CGT to instruct the student pilot to slow the aircraft was in response to his understanding of the busy nature of the circuit traffic, and would have assisted the student's ability to maintain situational awareness during the rejoin.

Despite the instructor's awareness of the PA-28, registered VH-MGV, on crosswind, the instructor's seating position in the aircraft's right seat and above the height of the climbing UPY probably explained his inability to see that aircraft. It was possible that, had traffic information been provided to CGT on UPY, there would have been an increased chance that the now-alerted student in the left seat of CGT would have identified UPY in sufficient time to avoid the midair collision.

Factors affecting visual acquisition

The display of additional lighting by both aircraft would probably not have made a significant change in aircraft conspicuity because of the likely overwhelming brightness of the ambient conditions. Similarly, the lack of significant colour, background contrast or relative movement of either aircraft increased the risk that neither pilot would detect an unexpected converging aircraft.

It is likely that both aircraft would have been visible to the respective student pilots near the edge of the windscreen. Although unable to be replicated exactly, any variability in the viewing pilot's head and seating position increased the risk that either or both aircraft could have been visually obscured from the other behind the respective aircraft's door posts, window frames or wing struts. In the case of the instructor in CGT, the magnetic compass that was located on the aircraft's windscreen centre pillar may have compounded the problem further.

Air traffic controller workload

The incorrect ATC instructions, lack of relevant and/or correct traffic information being passed to the respective aircraft and misunderstanding of the disposition of aircraft were indicators that the controller's situational awareness, and therefore management, of aircraft in his area of responsibility was degraded. Despite the controller believing that he was not working at his full capacity, the combination of the ADC W and surface movement control (SMC) frequencies, and the elevated traffic density and complexity prior to the collision increased the controller’s workload.

In addition, the likely effect on the ADC W’s performance of the already-high workload could potentially have been aggravated by the distraction of the returning SMC controller and handover of a number of operational tasks, and by the increased interaction with the two taxiing aircraft. In consequence, the opportunity for the controller to recognise and react to the potential of a collision between UPY and CGT was reduced.

A number of informal workload-management strategies were offered by controllers, including seeking help from other controllers or delaying or amending aircraft clearances in order to reduce traffic density in a controller’s area of responsibility. However, there was no formal guidance of the means to identify, mitigate or manage high controller workload situations if they arose. Instead, workload assessment and management relied on the judgement of the individual controller.

Moorabbin aerodrome - separation of traffic flows

Despite there being no separation standards for application to visual flight rules aircraft at GAAP aerodromes, it would appear that aspects of the concept of strategic separation assurance could enhance safety at the (at times) busy GAAP aerodromes around Australia. Indeed, most GAAP aerodromes applied vertical separation strategies to arriving and departing aircraft until they reached designated positions or received a joining instruction. Other GAAP aerodromes also applied lateral separation to inbound and outbound aircraft.

The lack of lateral or vertical separation between traffic flows at Moorabbin increased the risk of aircraft proximity events involving merging traffic flows. That emphasised the importance of the provision by ATC of directed traffic information or instructions to assist pilots to see and avoid other aircraft. The existence and management of ‘hot spots’, a locally-applied risk label, appeared to represent a local work around for that lack of separation of traffic flows at Moorabbin.

In addition, the provision of circuit-joining instructions to those aircraft when they were about 6 NM (11 km) from the circuit increased the possibility for a conflict to develop between the time when the circuit joining instructions were provided, and when the arriving aircraft actually joined the circuit. In consequence, the benefits of the provision of traffic information for increased pilot situational awareness relied on controller intervention shortly before the traffic flows at Moorabbin merged, such as when an inbound aircraft joined the circuit.

Airservices Australia Management system review alerts

The apparent lack of action by Airservices Australia (Airservices) to compare key performance indicators across GAAP airspace aerodromes in Australia denied Airservices an opportunity to identify any increased risk at those aerodromes and to develop strategies to manage that risk.

At Moorabbin, a check and standardisation supervisor had recommended a review of staffing levels to ensure continued safe and efficient operations. Since there was no evidence that review had been undertaken at the time of the accident, the investigation had no information available to it that might quantify the potential for the then staffing levels to have contributed to the midair collision.

FINDINGS

From the evidence available, the following findings are made with respect to the midair collision at Moorabbin Aerodrome, Victoria on 27 August 2008 involving Cessna Aircraft Company A150M aircraft, registered VH-UPY, and Piper Aircraft Corp PA-28-161 aircraft, registered VH-CGT, and should not be read as apportioning blame or liability to any particular organisation or individual.

Contributing safety factors

- The student pilot of VH-UPY did not see VH-CGT in time to prevent the collision.
- Neither pilot in VH-CGT saw VH-UPY in sufficient time to avoid the collision.
- The aerodrome controller - west did not provide the pilots of VH-CGT and VH-UPY with relevant traffic information about each other in sufficient time to assist self-separation.
- The aerodrome controller - west had been operating in a high workload environment in the period leading up to the midair collision. That increased the risk of traffic information not being able to be provided to flight crews.
- The Moorabbin Aerodrome General Aviation Aerodrome Procedures airspace design did not assure lateral or vertical separation between traffic flows. That increased the risk of a midair collision. *[Significant safety issue]*

Other safety factors

- Before the collision, the provision of relevant traffic information to pilots was sometimes incorrect or late.
- There was no evidence of any action taken by Airservices Australia to address safety recommendations related to a review of key performance indicators of General Aviation Aerodrome Procedure airspace operations. *[Minor safety issue]*
- The student pilot of VH-UPY had not yet demonstrated an ability to operate safely in a busy circuit environment and his flight instructor did not provide any guidance to the student in the situation were the circuit activity changed during the solo flight.

Other key findings

- There was no indication of any communication difficulties that could be attributed to the use and comprehension of English by the pilots or controllers involved.
- There was no indication of any significant factor in either student’s training that may have increased the likelihood of a midair collision.

SAFETY ACTION

The safety issues identified during this investigation are listed in the Findings and Safety Actions sections of this report. The Australian Transport Safety Bureau (ATSB) expects that all safety issues identified by the investigation should be addressed by the relevant organisation. In addressing those issues, the ATSB prefers to encourage relevant organisation to proactively initiate safety action, rather than to issue formal safety recommendations or safety advisory notices.

All of the responsible organisations for the safety issues identified during this investigation were given a draft report and invited to provide submissions. As part of that process, each organisation was asked to communicate what safety actions, if any, they had carried out or were planning to carry out in relation to each safety issue relevant to their organisation.

Airservices Australia

Moorabbin General Aviation Aerodrome Procedures airspace design

Significant safety issue

The Moorabbin Aerodrome General Aviation Aerodrome Procedures airspace design did not assure lateral or vertical separation between traffic flows. That increased the risk of a midair collision.

Action taken by Airservices Australia

In response to this safety issue, on 31 March 2011, Airservices Australia (Airservices) advised that:

> Airservices Australia thanks you for the opportunity to provide additional feedback in respect of the Safety Actions identified in draft report, as requested during our meeting on 21 March 2011.
>
> As stated in Airservices' initial response, we consider that there is insufficient weight of evidence or depth of analysis in the report to conclude, *'The Moorabbin Aerodrome General Aviation Aerodrome Procedures [GAAP] airspace design did not assure lateral or vertical strategic separation between traffic flows. This increased the risk of a mid-air collision '*.
>
> GAAP environments were not designed to provide strategic "separation assurance" between traffic flows. Separation within the GAAP environment was see-and-avoid and principally the responsibility of the pilot.

> Post incident, the change to Class D has removed the GAAP arrival routes and although designated inbound reporting points exist, aircraft can request clearance into the airspace from any point. In addition, consequent to the change to Class D, CASA implemented a change as per AIP [Aeronautical Information Publication] ENR [En Route] 12.3.6; unless ATC [air traffic control] specifically instructs otherwise, establishment of two-way communications permits a pilot, intending to land at an aerodrome within Class D airspace, to descend as necessary to join the aerodrome traffic circuit. Thus, the current airspace design and rule set means that strategic separation between traffic flows is not possible. To improve safety at Moorabbin, Airservices has, as stated in our original response, implemented the following:
>
> - Traffic, staffing levels and other identified threats at Moorabbin are now routinely monitored and reviewed in conjunction with the 'Metro D' and location specific Operational Risk Assessment (ORA).
> - Increased staffing at Moorabbin has alleviated the operational need to combine positions. The ADCW [aerodrome control – west] position at Moorabbin is now routinely operated as a standalone position except where low workload allows it to be combined with other positions. This enables the controllers to provide timely traffic information to aircraft.
> - Although prior to the incident controllers were assessed on workload management, the National ATS Procedures Manual (NAPM) now provides strengthened formal traffic management guidance to controllers. It includes a list of the factors a tower controller should consider in assessing the appropriate number of aircraft for circuit operations.

ATSB assessment of response/action

The ATSB is satisfied that the action implemented by Airservices Australia, in conjunction with the change of GAAP aerodromes to Class D that was implemented by the Civil Aviation Safety Authority on 3 June 2010 (see the following section titled *Civil Aviation Safety Authority*) will adequately address the safety issue.

Management of safety recommendations

Minor safety issue

There was no evidence of any action taken by Airservices Australia to address safety recommendations related to a review of key performance indicators of General Aviation Aerodrome Procedures airspace operations.

Action taken by Airservices Australia

Airservices Australia (Airservices) conducted its own investigation into the circumstances surrounding the midair collision. The Airservices investigation made the following recommendations:

> Review the effectiveness of the controls for the risk of aircraft operating in close proximity to another aircraft in the air at Moorabbin. This should include but not be limited to assessment of:
>
> facilities
>
> traffic volume

staffing levels

hours of coverage of the Tower service

recommendations from reports

The ADC W position at Moorabbin should be operated as a standalone position routinely except where low workload allows it to be combined with other positions.

Include operational risk assessment of changes to local conditions for all ATC units. This should include analysis of traffic volume and any other factors that could affect complexity of operations.

Review all roving check reports for Moorabbin and ensure all recommendations have been addressed or converted to a Safety Action Improvement Report (SAIR).

Specifically, to review the closure of the recommendation to conduct a review of

...any Key Performance Indicators (KPI) affecting GAAP to ensure an appropriate balance is maintained between financial, operational and safety decision making across the organisation

to ensure the action had been addressed.

Review operations at GAAP locations to identify and correct any local work practices that may have developed unchecked over time for reasons of expediency ahead of safety.

ATSB assessment of response/action

The ATSB is satisfied that the action proposed and implemented by Airservices Australia will, when complete, adequately address the safety issue.

Civil Aviation Safety Authority

Although no safety issues were identified as a result of this investigation in respect of pilot training for operations in General Aviation Aerodrome Procedures (GAAP) airspace, or of the utility of GAAP airspace for which the Civil Aviation Safety Authority (CASA) might have ownership, CASA has advised of the following proactive safety action.

General Aviation Aerodrome Procedures Training Review

As a result of a number of midair collisions in the vicinity of GAAP aerodromes, CASA initiated a GAAP Training Review, the results of which were released to the public in May 2009. The review identified three primary themes for enhancing safety that were based on training for operations at GAAP aerodromes:

- Situational awareness training and assessment is not being achieved in a consistent manner, with a lack of formal training tools available to assist instructors develop this safety critical competency;
- A general lack of standardisation, both within an individual flying school and at specific GAAP locations was observed; and

- A poor understanding of some fundamental GAAP procedural matters was detected.

The review developed 11 recommendations that addressed those themes, and provided supporting information to provide direction for implementing the recommendations.

The level of knowledge about the rules and procedures in GAAP airspace among the involved pilots was found to be adequate and accurate.

A full copy of the General Aviation Aerodrome Procedures Training Review is available on the CASA website at www.casa.gov.au

Review of the utility of General Aviation Aerodrome Procedures to Australian-administered airspace

A review of the utility of General Aviation Aerodrome Procedures airspace across Australia was carried out by an independent contractor on behalf of CASA. Following stakeholder feedback, a report was released on 15 December 2009.

The contractor's report produced 24 recommendations covering a wide range of potential safety enhancements, including the following:

- the establishment of strategic expert oversight for all Australian GAAP operations;
- future strategic safety enhancements, specific safety enhancements;
- planning to monitor changes to future airport activity that may affect safety, and methods for implementing change if it is deemed necessary;
- the acquittal of relevant ATSB recommendations issued in 2004; and
- limits on aircraft numbers operating GAAP circuit patterns.

On 15 July 2009, CASA issued a direction that had effect from 21 July 2009. The direction required that the number of aircraft in the circuit for one runway be limited to six, but allowing for one more aircraft to operate in the circuit with the intent of departing. The direction required all aircraft to obtain an Air Traffic Control clearance to enter, taxi along or cross any runway.

On 24 December 2009, the direction was amended so that the limiting number of aircraft would be increased to eight from 18 January 2010. That limit was to remain in force until Class D procedures were implemented at previously GAAP airspace aerodromes on 3 June 2010.

On 3 June 2010, Class D procedures were implemented at all aerodromes where GAAP procedures had previously been implemented.

On 21 April 2011, the ATSB sought an update from CASA of its actions in response to the recommendations of the above report. In response, on 9 May 2011, CASA provided the following update:

> I refer to your email dated 21 April 2011 seeking a Civil Aviation Safety Authority (CASA) update on any completed/planned actions in relation to recommendations from *The Utility of General Aviation Aerodrome Procedures (GAAP) to Australian-administered Airspace Review Report (Version 2 – 15 December 2009).*

The GAAP to Class D project involved an extensive national pilot education program focussed primarily upon operations at the then GAAP aerodromes. The program was widely acknowledged by industry as one of the most comprehensive and effective education processes ever undertaken by CASA. The transition at these locations has provided the following safety enhancements:

• increased alignment with international practice together with greater standardisation of procedures nationally;

• increased Air Traffic Control Tower staffing through the requirement to establish a permanent Surface Movement Control position, thus both providing increased capacity to monitor airborne traffic and enhancing ground movement safety;

• an ongoing program to remove compulsory Control Zone entry points providing additional flexibility for traffic management; and

• reduction in airborne radio congestion through the extended use of abbreviated clearances.

A Post Implementation Review has been undertaken to examine the outcome of the changes and is expected to be completed by mid 2011.

APPENDIX A: KEY EVENTS BEFORE THE COLLISION

The key events during the flights were as follows:

Number of aircraft operating in the circuit	UPY's circuit number	Time hh:mm:ss	Action
3	1	12:16:46	UPY cleared for takeoff.
4	1	12:18:44	Student pilot of UPY turned onto the downwind leg and aligned with runway 35, not the active runway 31.
4	1	12:19:25 and 12:19:55 and 12:21:16	Student pilot of UPY reported three times that he could not see the aircraft that he had been instructed to follow.
4	1	12:21:51	The aerodrome controller – west (ADC W) advised the student pilot of UPY that he had aligned his downwind leg with runway 35, not runway 31.
4	1	12:22:42 and 12:22:54	The ADC W gave the student pilot of UPY clearance for a touch-and-go.
4	1	About 12:23:30	The student pilot of UPY conducted a touch-and–go.
4	2	12:24:23	The pilot of NDR requested an early left turn after takeoff to position ahead of UPY in the circuit pattern.
4	2	12:25:20	The student pilot of UPY turned downwind. ADC W gave the student pilot an incorrect sequencing instruction.
4	2	12:26:54	The student pilot of UPY received a corrected sequencing instruction to follow NDR.
7	2	About 12:30:22	Second touch-and-go by the student pilot of UPY, which was carried out without the necessary clearance from the ADC W.
5	3	12:32:15	Student pilot of UPY reported on the downwind leg.
5	3	12:34:25	The pilot of CGT reported 6 miles (11 km) north-west inbound. The pilot was instructed to join the circuit on downwind for runway 31L and to report again at 3 miles (6 km). No traffic information was provided to that pilot by the ADC W.
6	3	About 12:35:39	Third touch-and-go by the student pilot of UPY, which was also carried out without the necessary clearance.
7	4	12:36:30	The controller was busy. The pilot of CGT reported at 3 miles (6 km) north-west of the

Number of aircraft operating in the circuit	UPY’s circuit number	Time hh:mm:ss	Action
			aerodrome, and received an acknowledgement from the controller.
7	4	12:36:35 to 12:37:23	ADC W communicated with the pilots of a number of aircraft on the ground at Moorabbin.
7	4	12:37:44	The ADC W advised the pilot of CGT of circuit traffic.
7	4	12:37:49	UPY was on late crosswind when it collided with CGT, which was joining the circuit on downwind from the north-west.

APPENDIX B: SOURCES AND SUBMISSIONS

Sources of information

The sources of information for the investigation included:

- the flight crew of VH-CGT (CGT)
- Airservices Australia (Airservices)
- the air traffic controllers
- the Civil Aviation Safety Authority (CASA)
- the aircraft operator.

Submissions

Under Part 4, Division 2 (Investigation Reports), Section 26 of the *Transport Safety Investigation Act 2003* (the Act), the Australian Transport Safety Bureau (ATSB) may provide a draft report, on a confidential basis, to any person whom the ATSB considers appropriate. Section 26 (1) (a) of the Act allows a person receiving a draft report to make submissions to the ATSB about the draft report.

A draft of this report was provided to CASA, the student and instructor pilots of CGT, Airservices, the air traffic controllers and the aircraft operator. Submissions were received from CASA, Airservices, the air traffic controllers, the flight crew and the aircraft operator. The submissions were reviewed and, where considered appropriate, the text of the report was amended accordingly.

Midair collision - 3 km NW of Moorabbin Airport, Vic
27 August 2008
VH-UPY, Cessna Aircraft A150M and VH-CGT, Piper Aircraft PA-28-161