This report for inquiry 10-008 is suppressed

until 10.00am on 28 March 2013

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Inquiry 10-008: Cessna 152 ZK-TOD and Cessna 152 ZK-JGB
mid-air collision near Feilding, Manawatu, 26 July 2010

TRANSPORT ACCIDENT INVESTIGATION COMMISSION
TE KOMIHANA TIROTIRO AITUA WAKA

Final Report

Aviation inquiry: 10-008
Cessna 152 ZK-TOD and Cessna 152 ZK-JGB mid-air collision near Feilding, Manawatu
26 July 2010

Approved for publication: 13 February 2013

Transport Accident Investigation Commission

About the Transport Accident Investigation Commission

The Transport Accident Investigation Commission (Commission) is an independent Crown entity responsible for inquiring into maritime, aviation and rail accidents and incidents for New Zealand, and co-ordinating and co-operating with other accident investigation organisations overseas. The principal purpose of its inquiries is to determine the circumstances and causes of occurrences with a view to avoiding similar occurrences in the future. Its purpose is not to ascribe blame to any person or agency or to pursue (or to assist an agency to pursue) criminal, civil or regulatory action against a person or agency. The Commission carries out its purpose by informing members of the transport sector, both domestically and internationally, of the lessons that can be learnt from transport accidents and incidents.

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Important notes

Nature of the final report

This final report has not been prepared for the purpose of supporting any criminal, civil or regulatory action against any person or agency. The Transport Accident Investigation Commission Act 1990 makes this final report inadmissible as evidence in any proceedings with the exception of a Coroner's inquest.

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Citations and referencing

Information derived from interviews during the Commission's inquiry into the occurrence is not cited in this final report. Documents that would normally be accessible to industry participants only and not discoverable under the Official Information Act 1980 have been referenced as footnotes only. Other documents referred to during the Commission's inquiry that are publicly available are cited.

Photographs, diagrams, pictures

Unless otherwise specified, photographs, diagrams and pictures included in this final report are provided by, and owned by, the Commission.

Cessna 152 ZK-TOD (Cessna A)
(Courtesy of Flight Training Manawatu)

Cessna 152 ZK-JGB (Cessna B)
(Courtesy of Flight Training Manawatu)

Source: mapsof.net

Location of accident

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Abbreviations

ACAS	airborne collision avoidance system
AIP	(New Zealand) Aeronautical Information Publication
ATC	air traffic control
ATSB	Australian Transport Safety Bureau
BEA	(France) Bureau d'Enquêtes et d'Analyses
CAA	Civil Aviation Authority of New Zealand
Commission	Transport Accident Investigation Commission
FAA	(United States) Federal Aviation Administration
hPa	hectopascal(s)
km	kilometre(s)
m	metre(s)
MHz	megahertz
MOU	memorandum of understanding
NTSB	(United States) National Transportation Safety Board
TAIC	Transport Accident Investigation Commission
TCAS	traffic alert and collision avoidance system
UTC	co-ordinated universal time
VFR	visual flight rules
VHF	very high frequency

Glossary

altitude	the vertical distance of an aircraft above mean sea level
control zone	that area of airspace surrounding an aerodrome extending from the surface to a specified upper limit and managed by a controller located in a tower
dual	an instructional flight with an instructor and student on board
height	the vertical distance of an aircraft above a reference point, normally the ground
Mayday	a distress call indicating a condition of being threatened by serious and/or imminent danger and of requiring immediate assistance
Part 135	Air Operations – Helicopters and Small Aeroplanes
QNH	an altimeter sub-scale setting to obtain elevation or altitude above mean sea level
solo	a flight by an unaccompanied student
stall	a reduction of lift caused by the breakdown of airflow over the wing when the angle of attack passes a critical point
track	the path of an aircraft over the surface of the Earth
traffic	a number of aircraft in operation
transponder	a device that on receiving an interrogation signal transmits an identifying signal. The reply may also include altitude information

Data summary

Aircraft particulars

Aircraft registration:	**ZK-TOD** (Cessna A)	**ZK-JGB** (Cessna B)
Type and serial number:	Cessna C152, 15280723	Cessna C152, 15284346
Number and type of engines:	one Lycoming O-235-L2C piston	one Lycoming O-235-L2C piston
Year of manufacture:	1977	1980
Operator:	Flight Training Manawatu	Flight Training Manawatu
Type of flight:	dual training	solo training
Persons on board:	2	one
Pilot's licence:	commercial pilot licence (aeroplane)	no licence (student pilot)
Pilot's age:	27	21
Pilot's total flying experience:	1566 hours (about 1210 on type)	74 hours (20 on type)

Date and time	26 July 2010, 1527 NZST[1]	
Location	near Feilding (Taonui) Aerodrome latitude: 40° 14.2´ south longitude: 175° 53.9´ east	
Injuries	2 fatal	nil
Damage	aircraft destroyed	major

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[1] Times in this report are New Zealand Standard Time (UTC + 12 hours) and are expressed in the 24-hour mode.

1. Executive summary

1.1. On Monday 26 July 2010, two Cessna 152 aeroplanes were being used for training flights in the vicinity of Feilding Aerodrome. One was climbing away from the aerodrome circuit with a solo student pilot on board and the other was returning to the aerodrome circuit with an instructor and another student pilot on board. The 2 aeroplanes collided at an altitude of 1300 feet – about 1100 feet above the ground.

1.2. The aeroplane with 2 on board lost part of one wing in the collision and became uncontrollable. It was destroyed when it crashed, killing both occupants. The engine on the other aircraft was damaged in the collision and soon stopped, but the solo pilot was able to glide the aeroplane back to Fielding Aerodrome and made a successful landing. That aeroplane was extensively damaged but the pilot was uninjured.

1.3. Both aeroplanes were flying in uncontrolled airspace under visual flight rules (VFR).[2] They were constrained by a 1500-foot altitude limit, above which was controlled airspace for aircraft flying into and out of Ohakea and Palmerston North Aerodromes. The 1500-foot limit meant that aircraft arriving at and departing Feilding Aerodrome were generally forced closer together than would be normal at other aerodromes.

1.4. The pilots of both aircraft were making the required radio calls announcing their locations and intended flight paths, but in spite of this neither the instructor nor the students appear to have recognised early enough to prevent the collision that they were on converging paths. The surviving pilot did not see the other aeroplane before the collision. It was not possible to determine if the flying instructor and student in the other aeroplane saw his plane before the collision.

1.5. One reason for the 2 aeroplanes colliding was that the pilots of both aircraft appear to have either not heard or heard and not comprehended the importance of the radio calls of the other aircraft. Radio calls reporting an aeroplane's position and intended flight path help pilots to build full mental pictures of the situation. Knowing what aircraft were in their vicinity would have helped the pilots to locate and avoid those aircraft, a concept known as "see and avoid". See and avoid is a fundamental requirement for flight under VFR.

1.6. The Transport Accident Investigation Commission (the Commission) made findings about the importance and known limitations of the see-and-avoid concept, the overall risk of mid-air collisions, and the use and viability of aircraft lighting and technology that could further reduce the risk of mid-air collisions involving general aviation aircraft.[3]

1.7. The Commission made 3 recommendations: the first on the requirement for instructors to ensure first the safety of their aircraft before attending to their students; the second for pilots to improve their active listening skills, to help form accurate mental plots of the locations of other aircraft and therefore assist in seeing and avoiding those aircraft; and the third for operators and pilots to use high-intensity strobe lighting to help ensure their aircraft are as visible as possible.

1.8. The key lessons learnt from the inquiry into this occurrence were:

- the first priority for an instructor, as the pilot-in-command, is to maintain command of their aircraft and ensure its safety before attending to the training needs of the student pilot

- pilots must make clear, concise, accurate and timely radio transmissions, and they need to listen actively to the transmissions of others to help build accurate pictures of what is occurring around them

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[2] Prescribed procedures and meteorological minima for flights by visual reference to the ground or water.

[3] In this context "general aviation" refers to non-airline aircraft.

- pilots need to maintain a good lookout and ensure that their scans cater for any blind spots in the cockpit, either by moving their heads to look around any obstructions or by manoeuvring their aircraft

- pilots need to be aware of the limitations of the human eye and understand how this can affect their ability to see and avoid other aircraft.

2. Conduct of the inquiry

2.1. The Commission was notified of the accident at about 1600 on Monday 26 July 2010 and immediately opened an inquiry under section 13(1)(b) of the Transport Accident Investigation Commission Act 1990. Two Commission investigators travelled to Palmerston North that evening and met with Civil Aviation Authority (CAA) staff who had worked with New Zealand Police to record and secure the accident site initially.

2.2. The Commission's investigators met with Police the next morning to co-ordinate the recovery of the 2 victims and the removal of wreckage. The site was cleared by about 1615 and the wreckage of ZK-TOD was taken to the Commission's facilities in Wellington for detailed examination and security.

2.3 In the next 3 days investigators examined ZK-JGB, the second aeroplane, interviewed local witnesses and met with the operator and staff. They also obtained radar recordings from Airways Corporation of New Zealand and weather information from the nearby Palmerston North and Ohakea Aerodromes.

2.4 The investigators obtained logbooks and flight training records for all 3 pilots, including written correspondence from overseas training establishments where appropriate. They also interviewed an instructor from a flight training organisation in South Africa, where one of the student pilots had begun their training.

2.5 On 22 September 2010 the Commission published an interim factual report on the accident. The report included a review of mid-air collisions and near misses in New Zealand and identified an apparent increase in the number of fatalities and collisions involving training aircraft in the previous 10 years.

2.6 On 26 July 2012 Commissioners approved a draft final report on the accident for consultation with interested persons. This report included draft findings and recommendations. Submissions were received on the draft final report, which Commissioners fully considered. They then made appropriate amendments to the report.

2.7 Two of the interested persons met with Commission staff in Wellington to discuss their submissions. One of these interested persons make a further oral submission to the Commissioners. As a result, follow-up interviews were held with 3 witnesses.

2.8 This final report includes: more factual information than the interim report; an analysis of that information; findings; and recommendations. Commissioners approved this report for publication on 13 February 2013.

Inquiry into flying training safety in New Zealand

2.9 As a result of this Feilding accident and a number of other fatal and near-fatal occurrences in New Zealand involving flying training, the Commission became concerned that systemic or widespread matters might be affecting flying training safety in New Zealand. It therefore opened a separate inquiry under section 8(2)(a) of the Transport Accident Investigation Commission Act 1990 to ascertain whether or not there were common factors or trends that may have contributed to the causes of these previous occurrences.

2.10 The findings of this inquiry will be contained in a report that will be available on the Commission's website www.taic.org.nz. This report examines whether or not flying training safety performance in New Zealand has improved or deteriorated. It also looks at specific issues relating to flying training safety in New Zealand, including the standard of flying training in New Zealand, the effects of increasing air traffic, the level of English language proficiency, radiotelephony communications, the New Zealand government funding structure for pilot training, access to weather information, and the flying training regulatory system.

3. Factual information

3.1. History of the flights

3.1.1. On Monday 26 July 2010 student A was programmed to do a dual training flight to practise the "overhead joining procedure" at Feilding Aerodrome, known locally as Taonui Airfield (see Figure 1). The student met with her instructor and after a pre-flight briefing prepared ZK-TOD, a Cessna 152 aeroplane, for the flight (for clarity this aeroplane is hereafter referred to as Cessna A). At 1503 the student and instructor took off. They completed 2 joining procedures, which involved vacating the immediate circuit area to the north, turning right and returning to overhead the aerodrome. Each join was concluded with a "touch-and-go landing"[4] on runway 28. See Table 1 for a summary of the sequence of events.

3.1.2. Shortly before Cessna A completed the second touch-and-go landing, another aeroplane from the same training organisation (Cessna C) took off from runway 28 and performed a simulated "engine failure after take-off" exercise.

3.1.3. After climbing out from the engine failure exercise, Cessna C flew a similar track to Cessna A as both aeroplanes headed to the north of the aerodrome. The instructor from Cessna C said that the 2 instructors radioed each other on the common local area radio frequency of 124.1 megahertz (MHz), to co-ordinate their flight paths. Cessna C continued north, while Cessna A climbed to about 1400 feet[5] before turning left and returning to the aerodrome. At about this time a general radio broadcast was made from Cessna A, advising other traffic that the aeroplane was to the north and joining overhead.

3.1.4. Also during this time an agricultural aeroplane was conducting topdressing operations on a paddock adjacent to the northern boundary of the aerodrome. The agricultural aeroplane was landing on runway 28 and, after loading, when there was no conflicting traffic, would depart using the reciprocal runway 10.

3.1.5. At 1523, as Cessna A became airborne from the second touch-and-go landing, the agricultural aeroplane landed and manoeuvred clear at the end of the runway to load. Shortly afterwards another Cessna C152 aeroplane, registration ZK-JGB, lined up on runway 28. This aeroplane is the one that later collided with Cessna A and is hereafter referred to as Cessna B. Cessna B had a solo student pilot on board (student B) and was also from the same flight training organisation as Cessna A. Student B made a radio broadcast that he was lining up on runway 28, followed shortly afterwards by another radio broadcast advising that Cessna B was taking off on runway 28. Student B was authorised for a solo flight in the Cheltenham training area to the north-east of the aerodrome (the same general direction of Cessna A) to consolidate general handling exercises and practise stalls and recovery.

3.1.6. At 1527 Cessna A was 3 nautical miles to the north-west of the aerodrome, near the eastern boundary of the town of Feilding, having just completed a left turn. Cessna A was being flown directly towards the aerodrome, now at about 1300 feet. Student B broadcast that he was on the crosswind leg and vacating to the training area. Cessna B was climbing through about 900 feet at this time. At 1527:36 the 2 aeroplanes collided at about 1300 feet.

3.1.7. Student B later said that the first he knew of the collision was when he heard a loud noise and the aeroplane being pulled down. As student B was about to make a distress or Mayday call he heard "Mayday" being transmitted from Cessna A. Others also heard the distress call and some thought "Mayday, engine failure" had been transmitted.

3.1.8. Shortly after hearing the radio transmission Cessna B's engine stopped, so student B entered a right turn back towards the aerodrome. He then transmitted a "Mayday" call and informed other traffic that he was returning to land.

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[4] A touch-and-go landing involves landing the aeroplane and almost immediately reapplying power to become airborne again, rather than bringing the aeroplane to a stop.

[5] Unless otherwise stated, the vertical distance of aircraft is reported as altitude – feet above mean sea level.

3.1.9. Cessna A was seen to enter a steep descending spiral dive before striking the ground, destroying the aeroplane and killing the 2 occupants. Student B was able to glide his aeroplane back to the aerodrome, landing on the side of the runway with the nosewheel trailing backwards. Student B was not injured.

Figure 1
Feilding/Manawatu area
(Courtesy of Google Earth)

Estimated Time	Event	Comment
1503:35	Cessna A takes off	Radar data
1507-1508	Cessna A calls north of the airfield (Colyton) joining	Interviews
1513	Cessna A completes first touch-and-go landing	Radar data
1517	Cessna A calls north of the airfield (Colyton) joining	Interviews
1522	Third Cessna takes off	Interviews
1523	Cessna A completes second touch-and-go landing	Radar data
1524	Agricultural plane lands	Interviews
1524	Cessna A turns crosswind	Radar data
1524	Cessna A and third Cessna co-ordinate flight paths	Interviews
1525	Cessna B calls lining up runway 28	Interviews
1525:45	Cessna A turns left towards Feilding, at 1400 feet	Radar data
1525-1526	Cessna B calls taking off runway 28	Interviews
1526-1527	Cessna A calls north-west of the airfield (Feilding) joining	Interviews
1525:55	Cessna B takes off	Radar data
1526	Agricultural plane takes off runway 10	Interview
1526:35	Cessna B starts crosswind turn	Radar data
1526:55	Cessna A completes turn back towards the airfield, at 1300 feet	Radar data
1527:00	Cessna B completes crosswind turn	Radar data
1527	Cessna B calls on crosswind vacating to training area (Cheltenham)	Interviews
1527:36	The 2 aeroplanes collide	Radar data
1529:08	Cessna B lands	Radar data

Table 1
Sequence of events

3.2. Site and impact information

3.2.1. The main wreckage of Cessna A was located in a grassed paddock 2.2 kilometres (km) to the north-north-west of the centre of Feilding Aerodrome.

3.2.2. Student B vacated his aeroplane where it had come to a halt on the side of the runway. Because the aeroplane was infringing on the active runway, engineering staff at the aerodrome photographed the scene and removed the aeroplane to a secure hangar. The engineers later reported that before removing the aeroplane they checked that the battery master switch was off, turned off the emergency locator transmitter and disconnected the battery.

ZK-TOD (Cessna A)

3.2.3. Cessna A had penetrated about 1.5 metres (m) into the firm ground, with the engine and fuselage remaining connected but severely damaged and compressed. The compression lines along the wings and fuselage showed that the aeroplane had struck the ground in a near-vertical attitude at high speed. Ground marks and the direction of impact marks along the wing of Cessna A were consistent with the aeroplane being in a spiral dive to the left at the time of impact.

3.2.4. Some light chord-wise scoring on the propeller blades, combined with twisting of the blades, indicated that the propeller had been rotating at the time of impact. Both wings had ruptured and the 2 fuel tanks were depleted of fuel. A strong smell of fuel was still present the day after the accident.

3.2.5. A rounded indentation and rubber transfer marks about the leading edge of the right wing, about 2 m inboard of the wing tip, approximated the dimensions and matched the tread of the nosewheel of Cessna B. Outboard sections of the right wing and the right aileron had detached from the aircraft as it descended and were found about 280 m to the north of the main wreckage. Other pieces of light material, for example Perspex and pieces of aluminium, were found scattered about the adjacent paddocks.

3.2.6. The wing flaps were in the retracted position. The degree of damage precluded any other useful instrument readings or control positions from being established. The damage to the headsets worn by the 2 pilots and the aeroplane radios precluded any useful testing of the aeroplane's communication system. The electrical switches located below the instruments were examined. The "rocker" type switches for several of the services were missing, but the switch for the anti-collision beacon was intact and found in the ON position. It could not be determined whether the switch had been ON before the impact or whether it had switched ON as a result of the impact.

ZK-JGB (Cessna B)

3.2.7. Cessna B had sustained major damage to the front of the aircraft. The nosewheel leg was still attached by a support bracket, but had been forced backwards. The engine carburettor was fractured, which was probably what had caused the engine to stop. The engine firewall displayed crease marks typical of those seen after a heavy nose-gear landing. The fairing at the base of the left wing strut had damage consistent with it having been struck by the nosewheel as it was pushed backwards. The aeroplanes flight controls were intact and operated as designed.

3.2.8. The altimeter pressure setting was set to 1019 hectopascals (hPa). The battery master switch was confirmed in the OFF position, with the anti-collision beacon and landing light switches in the ON position. The operator advised that it was normal practice to have both the anti-collision light and landing light on while operating in the local area. Student B's headset was found still plugged in to the aeroplane socket points.

3.2.9. Student B resumed his training several days after the accident. On his next flight he found that his headset was not operating correctly. He was unable to hear his own transmissions, and could not hear intercom or calls from his instructor and other aircraft. The headset had been purchased new by the pilot 5 weeks before the accident and he reported having had no problems with it during this time.

3.2.10. The headset was sent to an avionics specialist away from Manawatu for examination under the direction of the Commission. The specialist determined that the headset plug into the mono/stereo selector had 3 broken conductors and the lead from the switch into the ear shell had been pulled from its cable clamp. As a result there was no audio to the headphones. This would have prevented the wearer hearing any radio transmissions, including their own transmissions. The specialist considered that the pulled lead and broken conductors had most likely occurred as the result of a sharp tug on the lead.

Meteorological information

3.2.11. The weather at the time of the accident was reported by witnesses to be calm on the surface with a high overcast cloud cover.

3.2.12. Palmerston North Aerodrome is 7 km south of Feilding. The weather there 15 minutes after the accident was reported as:

Surface wind	280° magnetic at 10 knots
Visibility	50 km
Cloud	scattered at 2500 feet and broken at 4000 feet[6]
Temperature	11° Celsius
QNH (pressure)	1017 hPa
2000-foot wind	forecast 280° magnetic at 30 knots

3.2.13. Ohakea Aerodrome is 20 km west of Feilding. The weather there 15 minutes after the accident was reported as:

Surface wind	270° magnetic at 10 knots
Visibility	25 km
Cloud	scattered at 2500 feet and broken at 4000 feet
Temperature	13° Celsius
QNH (pressure)	1017 hPa
2000-foot wind	forecast 280° magnetic at 25 knots

3.2.14. At the time of the collision the sun was calculated to be on a bearing of 295° magnetic, at an elevation of 16° above the horizon, which was off to the side of each aircraft for the direction in which they were travelling leading up to the collision.

Aerodrome information

3.2.15. The Feilding Aerodrome was a non-certificated aerodrome[7] located 5 km south-east of Feilding at an elevation of 214 feet (65m) above mean sea level. The aerodrome consisted of one main bitumen runway, aligned about east-west and numbered 10 or 28 depending on the take-off and landing direction.[8] Grass area adjacent to the runway was also used by light aircraft, for example microlights and gliders.

3.2.16. The normal aerodrome circuit height was the standard 1000 feet above the aerodrome (1200 feet above mean sea level). The circuit direction was away from the hangar buildings, resulting in a left-hand circuit for runway 10 and a non-standard right-hand circuit for runway 28. The published joining altitude was 1500 feet (1300 feet above ground level).

3.2.17. The aerodrome was privately owned and there were reported to be about 100 aircraft based there. The aircraft types ranged from light aircraft, such as the Cessna 152, to gliders and microlights. There were also several agricultural and light twin-engine aeroplanes that operated from the aerodrome. It was not uncommon for non-radio-equipped aircraft to use the aerodrome, especially during the weekends and the summer months.

3.2.18. A Feilding Aerodrome users' group met annually and when major issues arose. The most recent meeting had been held on 23 August 2009. No minutes were kept of these meetings. The aerodrome operator advised that any significant safety issues were raised with the

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[6] Cloud was measured in eighths or oktas. Few was 1-2 oktas, scattered was 3-4 oktas and broken was 5-7 oktas. Total overcast would be 8 oktas.

[7] Civil Aviation Rules Part 139.5, effective 25 March 2010, directed that aerodromes serving any aeroplane having a certified seating capacity of more than 30 passengers and engaged in regular air transport operations were to be certificated and comply with the requirements of the Rule.

[8] Runways are referenced to the nearest 10° magnetic bearing, for example 280° magnetic is called runway 28.

Manawatu area users' group that included representatives from nearby aerodromes, air traffic services and the CAA.

3.2.19. In November 2008 the Manawatu users' group had developed a memorandum of understanding (MOU) with the objective of standardising practices with the intention of improving overall safety. In accordance with the MOU the local users' group met 6-monthly. A review of the minutes for the most recent meeting held on 30 March 2010 showed that the instructor in her role as chief instructor had attended as the representative of the operator and that no items concerning Feilding Aerodrome were discussed.

Local airspace information

3.2.20. Feilding Aerodrome was located in class G uncontrolled airspace, bounded by the Palmerston North Aerodrome and control zone to the south and the Ohakea Aerodrome and control zone to the west (see Figure 2 and Figure 3). Controlled airspace above the 3 aerodromes extended down to 1500 feet[9] and down to ground level in the 2 control zones. The Feilding area was a major transit route for aircraft flying north-south in order to avoid Ohakea and Palmerston North Aerodromes. In April 2009 the CAA published a "Good Aviation Practice"[10] booklet titled *In, Out and Around Manawatu* (CAA, 2009). The booklet was designed to help pilots flying in the area, and described Manawatu as "one of the busiest and most complex pieces of airspace in New Zealand".

3.2.21. Air traffic control (ATC) approval was required when operating above 1500 feet in the general Ohakea-Palmerston North-Feilding area. To facilitate training, ATC could activate a General Aviation Area to the north-east of Feilding, in which aircraft could operate uncontrolled up to 5500 feet. Aircraft were required to be fitted with radios and transponders when operating in controlled airspace. Pilots of radio-equipped aircraft operating in the Feilding "common frequency zone" were encouraged to make regular position reports, but the Good Aviation Practice booklet warned that some aircraft, in particular microlights, might not be radio or transponder equipped.

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[9] Altitude information is in reference to height above mean sea level.

[10] The booklet was one of a series of booklets covering specific aviation activities like mountain flying, and areas around New Zealand that warranted special attention by pilots.

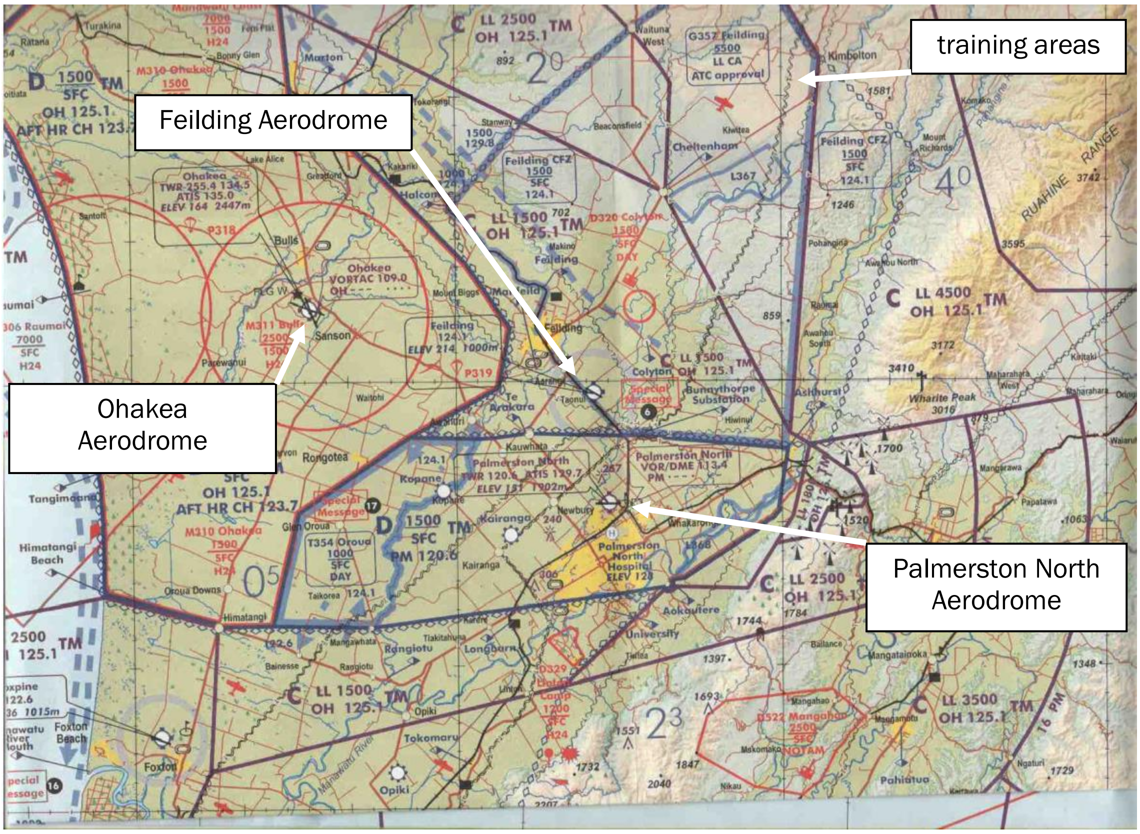

Figure 2
Manawatu airspace chart
(Courtesy of the CAA)

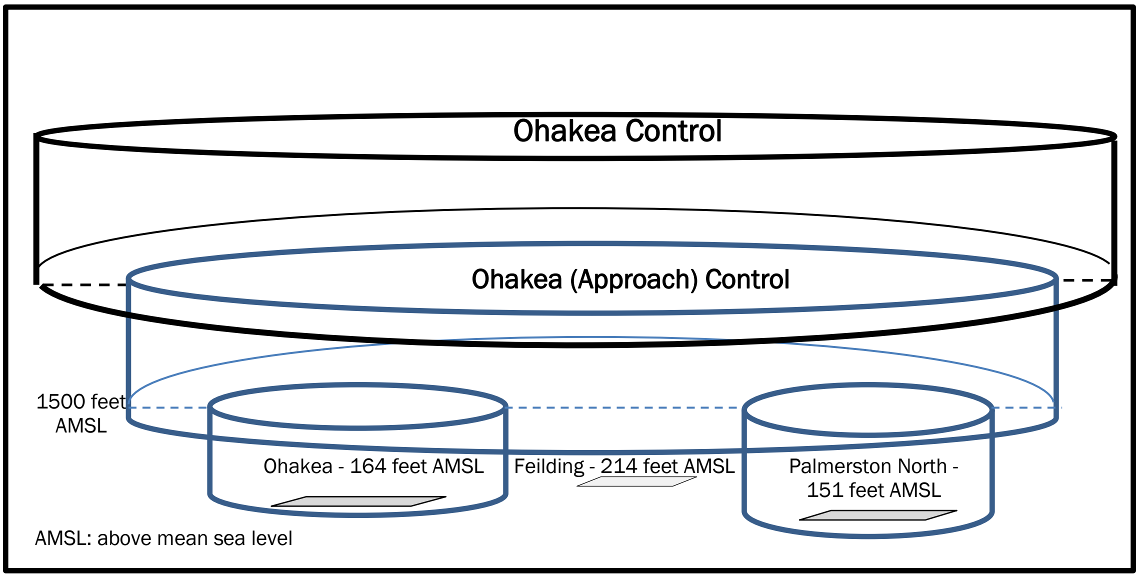

Figure 3
Airspace profile – schematic demonstration only

Communications

3.2.22. All radio-telephone transmissions from the aircraft referred to in this report were on the common aerodrome and local area frequency of 124.1 MHz. The transmissions were not recorded, nor were they required to be. At the time of the accident and in the 5 minutes leading up to it, there were the agricultural aeroplane and the 3 Cessnas flying in or near the circuit, all using 124.1 MHz. A radio located in an office of the flight training organisation was also tuned to this frequency.

3.2.23. Student B's instructor said that she had positioned herself in the office to be able to monitor student B's flight and ensure that he made the correct radio calls, as this was his first solo flight out to the training area. Also in the office during this time were 2 other instructors and 5 or 6 students. Students used the office as a break-out room for flight preparations and refreshments, which meant that they came and left the room often. The instructors and students recalled hearing all or parts of each of the radio transmissions from Cessna A and Cessna B.[11]

3.2.24. The pilot of the agricultural aeroplane stated that he could not recall hearing any transmissions from the "plane [Cessna B] that was holding" when he landed. He said he had been concentrating on his task and listening for those calls "that were relevant", for example aircraft joining overhead. Student B's instructor could not recall the exact content of his calls, but said she had heard the calls and "nothing in [the radio calls] had stood out as being non-standard". One of the other instructors said that he had heard student B transmitting the aeroplane call-sign and reporting "crosswind", but he could not recall the exact detail of the rest of the transmission. He also said student B's calls had been clear and easily understood. There were no reports of any clipped calls or transmissions made over the top of other radio calls leading up to the collision.

Aids to navigation

3.2.25. Airways New Zealand radar facilities recorded most of the flight paths of Cessna A and Cessna B on 26 July 2010.[12] At low altitudes the return signals were weak and tracking information became unreliable.

3.2.26. The radar data showed Cessna A taking off from runway 28 at 1503, turning right and flying to about 3 nautical miles north of the aerodrome. The aeroplane climbed to between 1300 and 1400 feet during this time. The aeroplane then turned right and flew back towards the aerodrome, crossing overhead the aerodrome before again turning right. After crossing the runway the aeroplane descended from about 1300 feet to about 1000 feet by about the time it again crossed the runway near the upwind end. The aeroplane then joined the downwind leg[13] of the circuit for runway 28, turned on to the base leg and completed a touch-and-go landing. The exercise was repeated a second time following a similar flight path (see Figure 4).

3.2.27. After the second touch-and-go landing, Cessna A again flew to the north of the aerodrome, climbing to 1400 feet, but this time made an almost continuous left turn back towards the aerodrome. During the turn the aeroplane descended about 100 feet to 1300 feet. The radar data showed that about the time when Cessna A entered the left turn, Cessna B became airborne from runway 28. After climbing to about 700 feet, Cessna B turned right and continued to climb.

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[11] The Commission received submissions questioning whether some of the radio calls had actually been made by the pilots involved in the collision. One witness questioned the number of people who had been in the office while the radio calls were made [those who had heard the radio calls]. That witness had been in the office but had left shortly before the collision. The Commission is satisfied that the number of people reported to be in the office when the various radio calls were made is accurate.

[12] Airways New Zealand was the certificated air navigation service provider responsible for air traffic services.

[13] The downwind leg is that portion of the circuit 180° to the landing direction, and is followed by the base leg and finals.

3.2.28. The 2 aeroplanes then maintained steady tracks as they approached each other – Cessna B climbing with a groundspeed of between 65 knots and 70 knots on a track of about 020° magnetic, and Cessna A on a track of about 140° magnetic with a groundspeed of between 90 knots and 95 knots. At about 1527:30 Cessna B levelled at 1300 feet. The data showed that the 2 aeroplanes collided at 1527:36, at a recorded altitude of 1300 feet (see Figure 5).

Figure 4
Radar recording of Cessna A (ZK-TOD)
(Courtesy of Airways New Zealand)

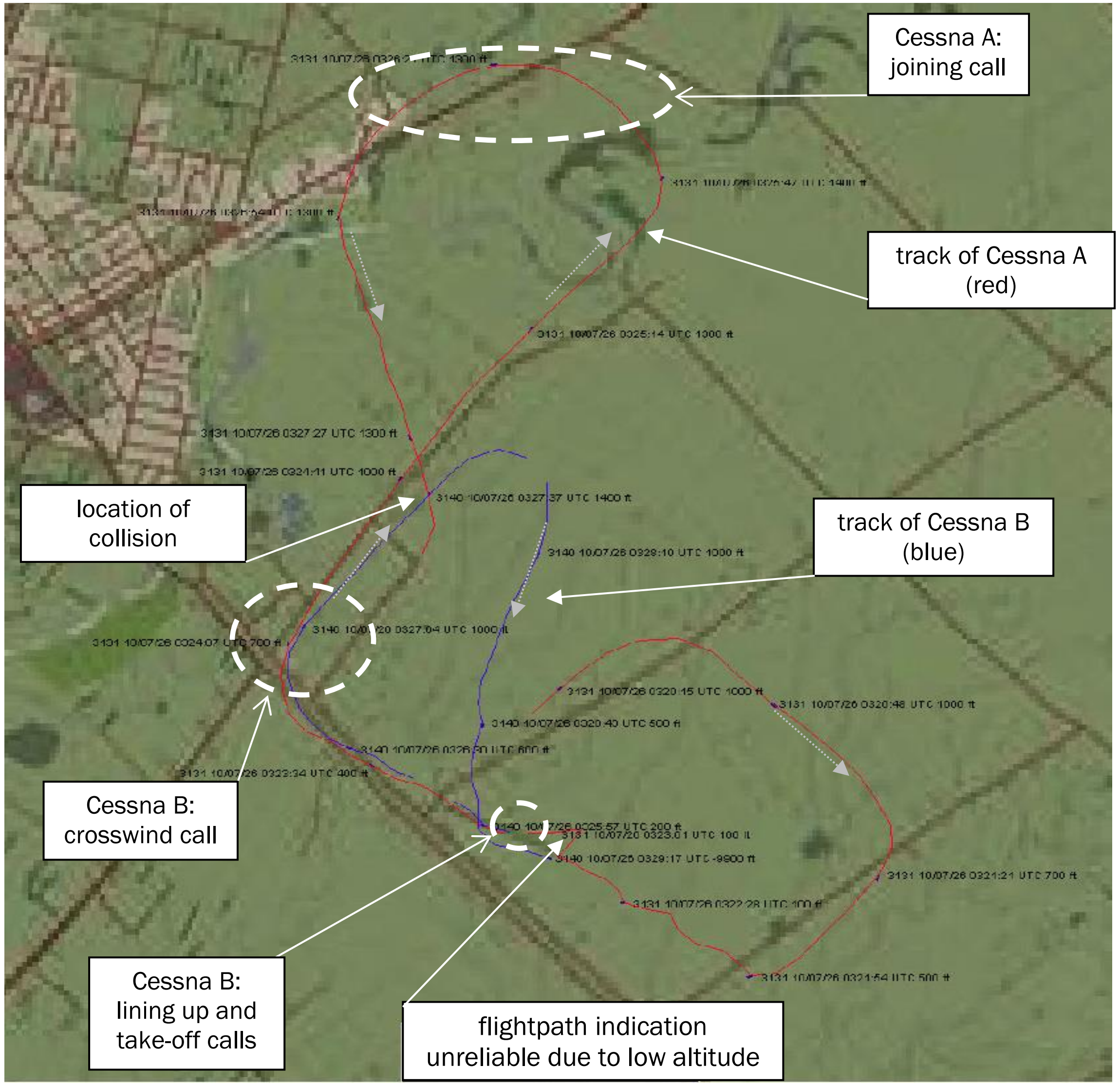

Figure 5
Radar recording of Cessna A and Cessna B
(Courtesy of Airways New Zealand)

3.3. Personnel information

3.3.1. The instructor was 27 years old. She had first started flying in February 2000, then took a break from training in July 2002. She had accrued 31 hours of flying at this time. In June 2003 she had recommenced her pilot training, going solo for the first time 3 weeks later. She had accrued a total of 41.4 hours at this time.

3.3.2. The instructor had obtained her private pilot licence on 6 October 2003, having accrued 105 hours of flying time, then obtained her commercial pilot licence on 22 July 2004, after 243 hours of flying. The instructor had then started working towards her flight instructor qualifications. On 17 March 2005 the instructor had passed her flight test on her second attempt and been issued with a "Category C Flight Instructor Rating – Aeroplane".

3.3.3. In December 2005 the instructor had moved to Botswana for 9 weeks, where she flew 13 hours on Cessna 206 type aircraft. The instructor had then returned to New Zealand, revalidated her ratings and instructed for a flight training organisation for 6 months. She had joined the operator in about November 2006, initially as a classroom lecturer only, and started flying instructing in mid-December 2006. On 3 April 2007, the instructor had passed the ground and flight examinations and been issued her "Category B Flight Instructor Rating (Aeroplane)".

3.3.4. In March 2008 the instructor had been appointed to the position of chief flying instructor. In that position she was responsible, together with the operator's chief executive officer, for management of the instructors and students and for the operator's continued compliance with the Civil Aviation Rules.

3.3.5. At the time of the accident, the instructor had accrued a total of 1566 flying hours, including about 1210 hours on the Cessna C152 type aeroplane. Her most recent Category B instructor renewal check had been on 5 July 2010, and most recent instrument rating check on 16 July 2010. These checks had been recorded as having also satisfied the biennial flight review requirement before one may exercise the privileges of an aeroplane commercial pilot licence. She also held a current Class 1 medical certificate valid until 9 June 2011. The certificate contained no conditions, restrictions or endorsements.

3.3.6. A review of the instructor's flying and medical records identified nothing of significance to the accident. The instructor was observed to be in good health on the day of the accident. The accident flight was her first flight of the day. Post-mortem and toxicology results were unremarkable.

3.3.7. Student A was 64 years old. She had taken up flying as an interest in February 2008, and gone solo for the first time on 19 June 2008, having flown 21.5 hours. Student A had begun flying with the instructor in May 2010. The accident flight was their fifth flight together and her seventh conducted from Feilding. At the time of the accident she had accrued 98 flying hours, including about 72 hours on the Cessna 152 type aeroplane.

3.3.8. Student A held a current Class 2 medical certificate valid until 27 March 2011. An endorsement on the certificate stated that she was to carry a bronchodilator inhaler when flying. Before the accident flight she was observed to be in good health and not suffering from any of the effects of asthma. Post-mortem and toxicology results were unremarkable.

3.3.9. Student B was 21 years old. He had started his flying training in June 2008 in South Africa and obtained a South African student pilot licence. He had first gone solo after 33.6 hours' flight training and subsequently accrued a total of 54.2 flying hours, including 7.6 hours solo. Information obtained by the Commission from the training school in South Africa suggested that the student, who had then been 19 years old, had struggled for a variety of reasons, including having difficulty adjusting to the foreign environment, so had returned home to India in December 2008.

3.3.10. Student B had arrived in New Zealand in March 2010 to continue his training towards the issue of a commercial pilot licence. Before travelling to New Zealand student B had been required to be vetted by the operator's agent in India. The vetting had included a medical examination and confirmation that student B's competency in communicating in English was satisfactory to allow him to commence his studies in New Zealand. Civil Aviation Rule 61.105 prescribed solo flight requirements, including the requirement to have "sufficient ability in reading, speaking, understanding and communicating in the English language" (CAA, 2008a).

3.3.11. Student B held a Class 1 medical certificate valid until 4 December 2010. He had no recorded medical conditions, restrictions or endorsements. He was observed to be in good health on the day of the accident, and said he had been fit to fly.

3.3.12. At the time of the accident, student B had flown a total of 74 hours, including 12 hours solo and 19 hours on the Cessna 152 type of aircraft. In the week before the accident he had flown 7 times, including 2 solo flights. He had had a day free of flying 4 days before the accident. The 5 instructional flights had included standard overhead joins, flying by reference to instruments and practising forced landings without power. The 2 solo flights involved a consolidation of standard overhead joining procedures and circuit training with multiple take-offs and landings.

3.3.13. At about 0830 on the day of the accident student B took off on a training flight with an instructor. The nearly one-hour flight involved flying by reference to instruments and the revision of stalling exercises. The instructor considered student B competent to undertake a solo flight in the afternoon to practise turning exercises in the training area, about 20 km to the north-east of Feilding Aerodrome. This would be student B's first solo flight to the training area, but he had flown solo to just clear of the circuit before. Student B then attended lectures until about 1300.

3.3.14. Student B had been scheduled to complete his "formal language evaluation" on 5 August 2010 (after the accident). Civil Aviation Rule 61.11 required applicants for pilot licences to have "sufficient ability in speaking, understanding and communicating in the English language to enable the applicant to adequately exercise the privileges of that licence" (CAA, 2008b). This evaluation was to be made against criteria set by the International Civil Aviation Organization and rated on a scale of 1 to 6. Level 4 (Operational) was deemed the minimum standard for a licence applicant and was valid for 3 years.

3.3.15. Student B completed his language evaluation as scheduled and was assessed as Level 5. Level 5 (Extended) remained valid for 6 years before a further evaluation was required. Level 6 (Expert) was the highest level and once awarded remained current for the lifetime of the holder of the pilot licence. The evaluation was performed by a CAA-approved organisation responsible for all evaluations undertaken in New Zealand.

3.3.16. On 19 April 2012, student B completed his assessment and flight test and was issued with a commercial pilot licence (aeroplane).

3.4. Aircraft information

3.4.1. Cessna A (ZK-TOD) and Cessna B (ZK-JGB) were both Cessna Aircraft Company 152 aeroplanes. The type was a 2-seat light aeroplane of all-metal construction, with a high wing and a fixed tricycle landing gear. The Cessna 152 was commonly used for flight instruction and was fitted with 2 sets of flight controls, one for the pilot or student who normally sat in the left seat, and one for the instructor who would normally sit in the right seat.

3.4.2. Cessna A had been manufactured in the United States in 1977 and allocated serial number 15280723. It was powered by a Lycoming O-235-L2C engine, serial number L-25687-15C. Cessna B had been manufactured in the United States in 1980 and allocated serial number 15284346. It was also powered by a single Lycoming O-235-L2C piston engine, serial number L-21033-15.

3.4.3. Each aeroplane had been issued with a standard category Certificate of Airworthiness, which was non-terminating provided the aeroplane was maintained and operated in accordance with the relevant operating limitations and manuals. A review of the documents for both aeroplanes recorded that they had been maintained in accordance with the operator's maintenance manual approved by the CAA.

3.4.4. On 26 July 2010 Cessna A had accrued some 5720 flying hours. The most recent maintenance action had been an annual review of airworthiness completed on 23 July 2010. On 24 June 2010 the aeroplane had undergone a routine 100-hour inspection. An entry in the maintenance logbook on 29 June recorded that the pilot's (left seat) microphone jack had been replaced after being reported as unserviceable.

3.4.5. The flight manual carried on board the aeroplane contained a page for recording "serviceability notes". The intention of this page was to allow the tracking between scheduled inspections of minor defects not affecting the airworthiness of the aircraft. The page contained 3 entries, one concerning the engine primer and a second concerning the alternator dropping off-line at low engine power settings. A third entry dated 24 July stated that the left-hand seat microphone jack was intermittently unserviceable. The instructor who had made that entry was also responsible for updating the technical log. That instructor said that the microphone had worked fine as long as the transmitting switch was held hard over, and that although the fault had been considered minor, he had made an entry in the technical log to have the microphone inspected at the next scheduled servicing. The instructor's microphone in the right-hand seat was fully functional. The aeroplane had about 10 hours to run until the next scheduled servicing, a 200-hour inspection.

3.4.6. On 26 July 2010 Cessna B had accrued some 11 722 flying hours. The most recent maintenance had been a routine 200-hour inspection completed on 2 July 2010. The aeroplane had 9 hours to run until the next scheduled maintenance, a 100-hour inspection. The annual review of airworthiness was due no later than 25 August 2010. The aircraft logbook contained no restrictions or faulty equipment that would have affected the safety of the flight.

3.4.7. Cessna B was equipped with a basic avionics suite, including one very high frequency (VHF) transceiver radio, a transponder and an encoding altimeter. Cessna A had 2 VHF transceiver radios, a transponder and an encoding altimeter. The VHF radios in both aeroplanes were updated solid-state radios. The transponders enabled altimeter information to be transmitted and displayed on ATC radar.

3.5. Operator information

3.5.1. Flight Training Manawatu had been originally established in 1993 as Feilding Aviation. The current owner had purchased the operation in 1997 and changed its trading name to Flight Training Manawatu. The operator also had a Part 135 commercial operation for which several of the pilots, including the instructor, flew.

3.5.2. The operator held a Civil Aviation Rule Part 141 flight training certificate and employed 14 full-time instructors, including 6 category B flight instructors (CAA, 2007). At the time of the accident the operator was training about 50 full-time students and several part-time students. Approximately one-third of the students were funded through the Tertiary Education Commission student funding scheme. The remainder were self-funded, with about half of these being from overseas. The operator had 13 aeroplanes, including 6 Cessna 152 aeroplanes.

3.5.3. The operator organised the instructors and students into "instructor teams". Each instructor was allocated 4 or 5 students and would normally retain their allocated students for each phase of their flying training. The more experienced instructors would also mentor 2 or 3 junior instructors. The chief executive and the chief flying instructor oversaw the operation, including the performance of the senior instructors.

3.5.4. Between 5 July and 9 July 2010 (3 weeks before the accident) the operator had been audited by the CAA as part of its regular audit schedule. The auditors made 3 findings, 2 in regard to maintenance support and the third in regard to the operator's Part 135 operation. The findings had been considered by all parties to be minor and rectified immediately after the audit. The flight training had been found to be operating effectively and, as no change to the operator's risk profile was indicated, no additional auditing had been considered necessary.

3.5.5. The operator noted that because the base of the controlled airspace above the aerodrome was at 1500 feet, there was a maximum buffer of only 300 feet between a joining aircraft and the circuit. Infringements into controlled airspace were a concern, so the standard overhead join was discouraged. Pilots returning to Feilding should have been familiar with the conditions and if they felt comfortable were encouraged to join the circuit on the downwind leg. If unsure of the conditions or returning after a significant time away from the area, flying the overhead joining procedure was considered appropriate.

3.5.6. The operator also commented that they did not consider the large number of international students to be a problem. While there could be some initial difficulties, for example learning local place names and getting used to the pace of speech, they soon adapted and became familiar with the local environment. Their conversational English and radio communications improved to an acceptable standard by the time the students were ready to fly solo. These sentiments were repeated by the operator's flight instructors, other local pilots spoken to, and air traffic controllers. These issues are discussed further in the Commission's report on flying training safety in New Zealand.

3.6. Other occurrences

Paraparaumu, 17 February 2008

3.6.1. On 17 February 2008, a mid-air collision between a light aeroplane and a small helicopter over Paraparaumu resulted in the deaths of 2 student pilots (aged 17 and 19 years) and a flight examiner (aged 30). Both aircraft were destroyed and several homes and commercial premises damaged, but no persons on the ground were injured (TAIC, 2008).

3.6.2. The pilot of the aeroplane was following a standard joining procedure for a sealed runway that took it into the path of the helicopter, which was operating in an opposing circuit direction for a parallel grass runway. The investigation determined that the 3 pilots had probably been concentrating on flying their aircraft and planned manoeuvres to the detriment of listening and maintaining an effective lookout. The pilots of both aircraft made the appropriate radio calls that should have alerted the other as to their position and intended flight path, but none of the pilots responded to the other's call and none appeared to take any avoiding action.

3.6.3. Mid-air collisions are rare events. Since the accident at Paraparaumu the regulator has issued a general reminder to pilots of circuit procedures at uncontrolled aerodromes, and issued improved aeronautical charts containing circuit and runway information for Paraparaumu Aerodrome, including the adoption of specific joining procedures.

3.6.4. In its Paraparaumu report, the Commission recommended to the Director of Civil Aviation that he act to increase his staff's promotion of the safe management of flying activities at all aerodromes and help educate pilots on effective visual scanning and active listening to radio calls. It was also recommended that the Director review operations at aerodromes around New Zealand with similar circuit patterns to help prevent future mid-air collisions.

New Plymouth, 10 May 2010

3.6.5. On 10 May 2010, a light helicopter and a light aeroplane, both of which were being used for dual pilot training, had a near-collision overhead the New Plymouth Aerodrome (TAIC, 2010).

3.6.6. The pilots of both aircraft were operating in accordance with their respective ATC clearances. The aeroplane was descending from overhead using the standard circuit joining procedure for a left-hand circuit for the runway in use, whereas the helicopter had been approved by ATC to operate above the normal circuit altitude in a right-hand circuit for the same runway. The aeroplane descended through the downwind leg of the helicopter's circuit.

3.6.7. The incident occurred because the crew of the aeroplane commenced their descent after losing sight of the helicopter and did not advise anyone of that. Contributory factors were the use of simultaneous opposed circuits, the aeroplane pilots' unfamiliarity with helicopter circuits, and the known limitations of the see-and-avoid concept for collision avoidance.

3.6.8. The investigation found that the aviation industry at large had not done enough to remove the risk of simultaneous opposed circuits at aerodromes, and that the Civil Aviation Rules and guidance for circuit joining, which were intended to reduce the risk of collision, could be improved to remove ambiguities.

3.6.9. The Commission made recommendations to the Director of Civil Aviation that he take action to address the following safety issues:

- The aviation community, from the regulator to operators, has not taken adequate action to remove the collision risk of simultaneous opposed circuits at aerodromes. Simultaneous opposed circuits can exist as a result of locally agreed procedures at uncontrolled aerodromes, and also at controlled aerodromes under certain conditions.
- ATC, having cleared an aircraft to make a non-standard circuit, may clear a subsequent aircraft to join the circuit by the standard overhead joining procedure, even though that can lead to a head-on traffic conflict.
- The descriptions and requirements for the standard overhead circuit joining procedure that are published in CAR [Civil Aviation Rules], the AIP [New Zealand Aeronautical Information Publication] and the Flight Instructor Guide are not entirely consistent or clear, particularly if a preceding aircraft is operating in a non-standard circuit, which could contribute to the collision risk at aerodromes.
- In controlled airspace where separation is not provided between aircraft operating under VFR, a VFR aircraft that is instructed to follow another aircraft is not explicitly required to promptly advise ATC if visual contact is lost with the relevant traffic.

3.6.10. The investigation provided reminders of practices that contributed to aviation safety. Those considered relevant to the Feilding accident included:

- To minimise the collision risk, pilots must combine an effective lookout with an attentive listen-out, especially in the vicinity of aerodromes.
- Pilots should advise, by broadcast if appropriate, when relevant traffic is no longer in sight.
- The see-and-avoid principle continues to have relevance, provided pilots and controllers counter its well-known limitations by the appropriate sharing of traffic information.
- Civil Aviation Rules and Aeronautical Information Publications must be written carefully and explained clearly to avoid ambiguity.

3.7. Civil Aviation Rules and procedures

Rules

3.7.1. Rules on "right of way" and "operating on and in the vicinity of an aerodrome" were contained in Civil Aviation Rule Part 91 General Operating and Flight Rules. Rule 91.127 *Use of aerodromes* detailed the conditions on the use of an aerodrome and included the requirement to comply with notified limitations and operational conditions (CAA, 2010).

3.7.2. Rule 91.223 *Operating on and in the vicinity of an aerodrome* directed pilots to observe other aerodrome traffic for the purpose of avoiding collisions and to conform with or avoid the traffic circuit formed by other aircraft. For runway 28 at Feilding, pilots were to perform a right-hand aerodrome traffic circuit, which meant that all turns in the aerodrome circuit and when immediately joining the runway 28 circuit were to be turns to the right. Rule 91.227 *Operating near other aircraft* directed that no pilot was to operate an aircraft so close to another aircraft as to create a collision hazard.

3.7.3. Rule 91.229 *Right-of-way rules* directed all pilots, when weather conditions permitted, to maintain visual lookouts so as to see and avoid other aircraft. The Rule described various situations where collisions might occur, including head-on, converging, overtaking and landing. For the converging situation the Rule stated: "A pilot of an aircraft that is converging at approximately the same altitude with another aircraft that is to its right, must give way". The Rule then noted several exceptions that were not applicable to this accident scenario. Regardless of who had the right of way, all pilots were still required to take such actions as necessary to avoid collisions.

3.7.4. Rule 91.239 *Altimeter settings* directed pilots to set the altimeter to an appropriate QNH zone setting or aerodrome QNH altimeter setting. This helped to ensure that pilots in the same area were operating to a common altitude reference. Pilots interviewed as part of the investigation, including instructors and students from the operator, advised that it was normal practice to set the altimeter to the aerodrome elevation before departure, or possibly to the Palmerston North Aerodrome setting if this could be obtained.

3.7.5. Rule 91.301 *VFR meteorological minima* stated that when flying in the vicinity of an aerodrome in uncontrolled airspace the meteorological minima required for flights to operate under VFR were a minimum cloud ceiling of 1500 feet and minimum visibility of 8 km.

Joining procedures

3.7.6. The procedures to be followed at aerodromes were contained in the New Zealand Aeronautical Information Publication (AIP). Some aerodromes around New Zealand, mainly aerodromes with air traffic services, had specific joining procedures for pilots to follow. However, most uncontrolled or unattended aerodromes did not. The AIP stated that the standard overhead joining procedure should be followed at unattended aerodromes (where no ATC or flight information service was provided) and at other aerodromes when a pilot was unfamiliar with the aerodrome or was uncertain of circuit traffic. The standard overhead join was identified as a means of compliance with Rule Part 91.223, referred to in paragraph 3.7.2 (CAA, 2008d). The CAA Flight Instructor Guide also informed pilots that the standard overhead join procedure is a recommended means of complying with the Rule.

3.7.7. On 26 July 2010, the instructor and student A were practising the "standard overhead joining procedure" as part of the pilot training syllabus. The Aeronautical Information Publication described the joining procedure as follows (see Figure 6):

(a) If radio equipped, advise local traffic of joining intentions.

(b) Approach the aerodrome by descending or climbing to not less than 1500 feet above aerodrome elevation or not less than 500 feet above circuit height.

(c) Pass overhead the aerodrome in order to observe wind, circuit traffic and any ground signals displayed. Continue circuiting at 1500 feet until satisfied.

(d) Make all subsequent turns in the direction of the traffic circuit.

(e) Once the conditions in (c) are ascertained, cross to the non-traffic side, and descend to circuit height.

(f) Turn 90° across the wind and pass sufficiently close to the upwind end of the runway to ensure that aircraft taking off can pass safely underneath.

(g) Turn to join the downwind leg of the traffic circuit at a point that ensures adequate spacing with any aircraft in the circuit ahead or behind.

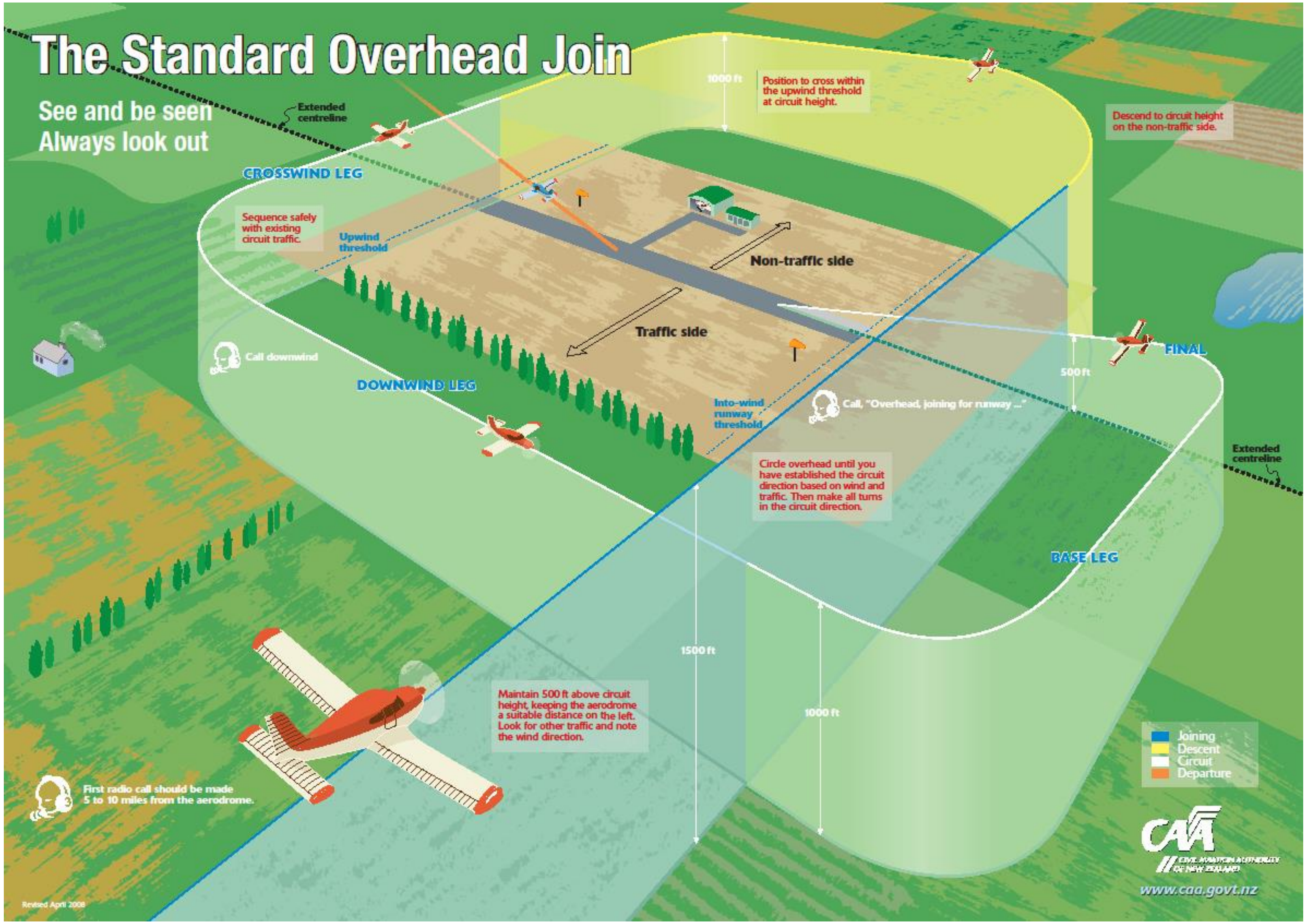

Figure 6
Standard overhead joining procedure
(Courtesy of the CAA)

3.7.8. The CAA also distributed educational material on the joining procedure to licensed pilots and operators, including flight training organisations. The material included instructor guidance information, posters and magazine articles that described the standard joining procedure and right-of-way requirements. The diagrams portraying the joining procedure were representative and the pattern might vary depending on weather conditions, other traffic and aircraft performance or design considerations.

3.8. Mid-air collisions

3.8.1. The investigation into the Paraparaumu accident identified 12 mid-air collisions that had occurred in New Zealand in the previous 20 years. Seven of the collisions had resulted in fatalities, with 20 people killed. Half of the collisions had involved aircraft participating in some form of formation or pre-planned, close-proximity activity, for example filming. All of the collisions had occurred during daylight in good weather conditions with the pilots operating under VFR. The collisions had all occurred in uncontrolled airspace and 5 had occurred in or near an aerodrome or circuit environment. The Feilding accident was the sixth to occur near an aerodrome.

3.8.2. Reports into mid-air collisions by the United States Federal Aviation Administration (FAA, 1983), the Australian Transport Safety Bureau (ATSB, 2004 & 2008) and the French Bureau d'Enquêtes et d'Analyses (BEA, n.d.), and a report by the Transport Safety Board of Canada (TSB, 2006), all identified similar characteristics. They found that mid-air collisions occurred mostly in or near the circuit and in visual meteorological conditions. The Australian study determined that in the majority of collisions there was evidence to suggest that the pilots involved had made appropriate radio broadcasts prior to the collisions. The United States' review determined that "inadequate visual lookout – failure to see and avoid" remained the most common causal factor. About 88% of the pilots involved in mid-air accidents had not seen the opposing aircraft in time to take evasive action. None of the reports identified a relationship between pilot experience and the incidence of mid-air collisions.

3.8.3. The study by BEA of mid-air collisions between 1989 and 1999 concluded "that all pilots whatever their age, their qualification or flight rules applied can be confronted with the risk of mid-air collision. The number of these accidents is low, but they often have serious consequences". The study also concluded that:

> *The increasing number of aircraft, the complexity of certain routes, the improved performance and ergonomics of cockpits should incite pilots to use all means available in order to detect and to be detected by others.*
>
> *Finally, regulatory developments are indispensable because the see-and-avoid rule is often the only guarantee of avoiding collision. This basic rule, in a context where there are more and more constraints, is no longer adequate.*

3.8.4. In response to questions raised by the Commission about its study, BEA advised that there had been no change to the rules since the study and that "the 'see-and-avoid' principle remains the basis of collision avoidance for VFR flights, whatever the airspace class. There is no expected change to this". BEA also advised that there was no mandatory use of airborne collision avoidance systems (ACASs)[14] for light aircraft and no plans to change the rules regarding separation in uncontrolled airspace.

3.8.5. In respect of joining an uncontrolled aerodrome, BEA advised that "the regulations require the pilot to evaluate the parameters at a height above the circuit height, then to enter the circuit at the beginning of the downwind leg". Other than meeting these requirements there was no standardised procedure or prescribed height above the circuit for the overhead join.

3.8.6. On 3 June 2010, the Australian Civil Aviation Safety Authority introduced new procedures for operations at non-towered aerodromes. The changes were "aimed at reducing the risk of mid-

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[14] ACASs come in many forms, from a simple alerting system that warns a pilot to the presence of another aircraft, to more sophisticated equipment that provides traffic location and, if required, avoiding action to follow.

air collisions by maximising separation at aerodromes without air traffic services" (CASA, 2010). The changes included the requirement to carry and use a radio when flying at or in the vicinity of a certified, registered or military aerodrome that was non-towered.[15] Non-towered aerodromes by definition were located in uncontrolled class G airspace.

3.8.7. The new procedures prescribed different circuit heights for different aircraft types: 1500 feet for high-performance aircraft, 1000 feet for medium-performance aircraft, and 500 feet for low-performance aircraft. The requirement to make radio broadcasts at specific locations within the circuit, and when joining or flying near an aerodrome, was also prescribed.

3.8.8. Pilots were recommended to join the circuit on the downwind leg, either from an extension of the downwind leg, a 45° angle about halfway down the downwind leg, or from a shortened crosswind leg. Joining straight in on a long final approach was allowed but not recommended. If unfamiliar with the aerodrome layout, circuit direction or conditions, pilots were recommended to overfly or circle it at least 500 feet above circuit altitude. Pilots were to descend on the non-active (dead) side of the circuit when satisfied of the conditions. This manoeuvre was similar to the CAA-promoted standard overhead joining procedure.

New technology

3.8.9. Technology that was once the preserve of large airliners is now being incorporated into light aircraft. Analogue flight instruments have been replaced by electronic displays, supplemented with new equipment such as the global positioning system, or GPS as it is commonly called. Called glass cockpits or technologically advanced aircraft, the new technology has allowed general aviation pilots to access a greater array of information. Other equipment like ACASs, for example the traffic alert and collision avoidance system (TCAS), can also provide an additional defence against mid-air collisions.

3.8.10. A Commission investigation into a loss of separation and near collision between a light aircraft and an airliner determined that the actions of the crew of the airliner in following the ACAS instructions prevented a collision (TAIC, 2010). A report by the United States Aircraft Owners and Pilots Association (AOPA 2007) noted that "since the advent of TCAS there has not been a single GA [general aviation] versus airliner or airliner versus airliner collision in U.S. airspace". However, the report also noted that a casualty of the use of modern technology was "a good see-and-avoid lookout for other aircraft".

3.8.11. In March 2010, the United States National Transportation Safety Board completed a safety study on glass cockpit avionics in light aircraft (NTSB, 2010). The study found that regardless of experience, pilots converting to glass cockpit aircraft needed specific additional training. A statistical analysis found that light single-engine aircraft equipped with glass cockpit displays experienced lower total accident rates – but higher fatal accident rates – than the same type of analogue-equipped aircraft.

3.8.12. In discussions with the Commission's investigator, the co-author of the study advised that considerable time had been spent reviewing the accidents looking for discernible trends, including for mid-air collisions. No identifiable differences in the occurrences of mid-air collisions associated with modern technology could be identified.

3.8.13. Five of the largest pilot training providers in New Zealand were contacted and asked about the use of ACASs. One of the providers advised that it had recently completed a trial installing an ACAS in one of its aircraft. The provider considered that the ACAS was inaccurate and was not alerting the pilots to some aircraft that could be seen visually. It had also proved to be a distraction for the pilot and their general situational awareness reduced as a result. The training provider concluded that the ACAS created additional risk and would not be used.

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[15] Certified aerodromes had runways capable of handling aircraft with more than 30 passengers or 3400 kilograms of cargo, and were available for regular public transport or charter operations by such aircraft.
A registered aerodrome was registered under Civil Aviation Safety Regulation subpart 139.C, met certain minimum operating standards and was regularly inspected.

3.8.14. A second provider advised that its new fleet of single-engine aircraft had come fitted with a traffic advisory system – a form of ACAS. It considered that the advisory system enhanced pilots situational awareness but was secondary to maintaining an effective visual lookout. New students had to demonstrate good see-and-avoid skills before being allowed to start using the ACAS, and then only under certain conditions. The provider considered this essential as the ACAS would still not detect aircraft without working transponders. The decision to fit the ACAS to its fleet of twin-engine aircraft had been deferred because of the high cost.

3.8.15. The remaining 3 providers, including one located at Ardmore, the busiest aerodrome in New Zealand, advised that none of their fleets was fitted with an ACAS and they had no plans to do so. Senior instructors from each of the 3 providers had flown in ACAS-equipped aircraft, and their experience had been that it became a distraction and was a hazard in high-density environments like the circuit and training area. Their emphasis was on teaching an effective lookout complemented by good radio procedures, including listening. One of the providers also commented on the need for good decision-making and cockpit discipline. All 5 providers considered that the principle of see and avoid worked and had to be complemented by good radio procedures.

4. Analysis

4.1. General

4.1.1. Feilding is a busy aerodrome, with a significant number of aircraft based there. It is also located between 2 other busy aerodromes (Ohakea and Palmerston North) and near a popular route for aircraft transiting north and south and keeping clear of the 2 control zones. Pilots training at Feilding were required to operate in a constrained airspace because of the 2 other adjacent controlled aerodromes and the controlled airspace above 1500 feet over Feilding Aerodrome itself. With the variety of aircraft using the aerodrome and local area, including non-radio-equipped aircraft, pilots needed to maintain a high level of awareness and a good lookout.

4.1.2. CAA publications alerted pilots to the hazards of operating in and around the Manawatu region. While ATC services provided traffic flow and separation in controlled airspace, including at Palmerston North and Ohakea, Feilding Aerodrome was in uncontrolled airspace and had no specified arrival and departure procedures. Pilots were therefore required to ensure their own separation and where possible follow standard procedures.

4.1.3. Feilding Aerodrome can be busy, but this accident took place on a Monday afternoon and it was winter. The aircraft traffic in the area at the time was not significant, and the 2 aeroplanes involved were close to, but not actually in, the aerodrome circuit.

4.1.4. The pilots of the 2 aeroplanes were undertaking routine training flights at the time of the collision. The weather was suitable for the exercises being undertaken and there were no personal, aeroplane or environmental issues that should have impeded the pilots performing their duties.

4.1.5. The issues of air traffic management around Feilding Aerodrome are discussed later in the analysis, but the key safety issues discussed are the pilots of both aircraft not appearing to have formed accurate mental pictures of where other aircraft were in relation to their own, and why they did not appear to see each other in time to prevent the collision.

Finding

Feilding Aerodrome and the airspace around it, and the variety of aircraft that used and transited over the aerodrome, could at times create a busy and complex environment for student pilots and instructors to deal with. However, at the time of the accident the aerodrome was not busy and there were no unique challenges identified that might have contributed to the collision.

4.2. What happened?

4.2.1. The 2 aeroplanes collided at an altitude of about 1300 feet and at an angle of about 120° (see Figure 7). The closure speed was calculated to be between 130 and 145 knots (about 240-270 km per hour).

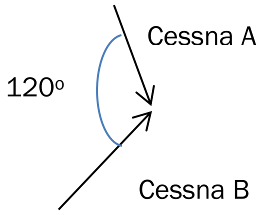


Figure 7
Collision angle

4.2.2. The radar recordings and the nature of the damage to both aeroplanes indicated that both aeroplanes maintained constant tracks for the 30 seconds prior to the collision. Student B said that he had not seen Cessna A until after the collision. The steady course maintained by Cessna A leading up to the collision suggests that its pilots were not expecting a conflict with the other aeroplane, and did not see it in time to take avoiding action. Whether they saw it immediately before the collision will never be known, but it remains a possibility.

4.2.3. Cessna A was joining the circuit, so according to Civil Aviation Rules its pilots were required to locate other aircraft in the circuit so that they could avoid them and fit into the circuit pattern. The pilots of Cessna A made the appropriate radio call advising local traffic of their position and intentions. Cessna B was in the process of vacating the circuit and its pilot had made the appropriate radio calls advising its position and intentions also. The pilots of both aeroplanes should have been listening for those calls and assessing how the intended track of the other aeroplane might affect their own plans.

4.2.4. Civil Aviation Rules stated that when 2 aircraft were converging, the aircraft with the other on its right had to give way. In this case Cessna A would have been required to give way to Cessna B, provided the pilots knew of its whereabouts and had seen it.

4.2.5. Notwithstanding the above, the Rules required the pilots of both aeroplanes to see and avoid other traffic and take appropriate action to prevent a collision, regardless of who was supposed to give way. This means that the student pilot of Cessna B was also obligated to look for other traffic and to avoid it.

4.2.6. Student B reported having heard through his headset the transmissions from other aircraft, including the agricultural aeroplane and the aeroplane taxiing and taking off before him, the distress call from Cessna A and his own transmissions. Other pilots, instructors and students were able to hear student B's transmissions before and after the collision, although none could recall the exact content of all radio transmissions.

4.2.7. Pilots might not necessarily listen attentively to the content of all radio transmissions; generally only those that they recognise or assume could pose a threat to their own aircraft. For example, the other students and instructors in the office might have heard radio transmissions as background noise because they were not actually flying aircraft at the time. Likewise the pilot of the agricultural aeroplane was aware of Cessna B when he landed, but was focused on his tasks and reacting to those aircraft joining that might affect him. However, student B's instructor on the day was in the office in the minutes leading up to the collision, so she was listening more attentively to his transmissions because she was responsible for monitoring his performance. This point is made to explain why one witness not hearing or noting a call does not necessarily mean that the call was not made.

4.2.8. Student B said that he could not recall hearing the last position report made from Cessna A. There are several possible explainations for this. An intermittent problem with his headset was one possibility. However, the headset was near new and he had not had any previous problems with it. He clearly heard the other transmissions and others had heard his radio calls. It was therefore unlikely that his headset was the problem. A more logical explanation is that he simply did not comprehend the importance of the radio message while focusing on the task of vacating the circuit area. The damage later found with student B's headset more likely occurred when he left the aeroplane rapidly, possibly having forgotten to remove it first. This possibility is supported by one witness who described Student B's exit from the aircraft as "I have never seen anyone exit an aircraft so quickly after landing".

4.2.9. The possibility that student A's microphone jack intermittently failed during the flight cannot be excluded. However, the transmissions from Cessna A indicated nothing untoward. The pilots were earlier able to communicate with Cessna C as they both headed northwards away from the aerodrome. Several listeners heard their general broadcast about joining overhead made shortly before the collision and several heard the distress call after it.

4.2.10. The Commission has concluded that the communication equipment in both aeroplanes was working normally and was not a factor in this accident.

4.2.11. The nosewheel of Cessna B struck the outboard right wing of Cessna A. The impact caused the outboard 2 m of the wing of Cessna A, including the aileron, to separate, which rendered the aeroplane uncontrollable. One of the pilots on board Cessna A transmitted a distress call, which might have included reference to an engine failure. Dealing with an engine failure would be a distraction that could cause pilots to lose awareness of their surroundings, so the possibility that Cessna A suffered an engine failure prior to the collision must be considered. However, if an engine failure had occurred Cessna A would have begun to lose height earlier. The radar records show that Cessna A maintained a steady altitude until the collision, so it was therefore unlikely that the engine failed before the collision. The scenario of a simulated engine failure is commonly used during a pilot's training to initiate an emergency response. If the words "engine failure" were used, that could possibly have been an automatic reaction if the pilots were unaware of what had caused the sudden departure from controlled flight.

4.2.12. Despite the engine of Cessna B stopping, student B was able to glide back and land on the grass beside the runway. The damage to the engine carburettor would have caused the engine to stop. This damage was probably caused by the nosewheel and engine being forced back when they struck the wing of Cessna A.

Findings

The nosewheel of Cessna B struck and severed part of Cessna A's wing, rendering Cessna A uncontrollable, causing it to crash.

The nosewheel and engine of Cessna B were forced back, damaging the engine carburettor and causing the engine to stop. However, the aeroplane was still controllable, allowing the pilot to make a successful emergency landing.

The communication equipment in both aeroplanes was working and there was no evidence that a technical failure contributed to the collision.

4.3. Listening for, seeing and avoiding other aircraft

4.3.1. The Commission has recently investigated one other mid-air collision and one near collision, both involving training flights. In each occurrence the weather was suitable for the flights and was not a contributory factor. The conditions at Feilding were above the minima required for flight by VFR. The wind was calm at the surface and there were no reports of any turbulence at the altitudes at which the aeroplanes were being flown.

Seeing other aircraft

4.3.2. Pilots of all aircraft are required, when weather conditions permit, to maintain visual lookouts so as to see and avoid other aircraft. For pilots operating under VFR the principle of see and avoid is a primary means of avoiding collisions with other aircraft. The pilots of both these aircraft should have been able to see each other, but see and avoid does have limitations. Pilots need to be aware of these limitations and apply effective techniques to detect potentially conflicting aircraft early enough to take appropriate avoiding action.

4.3.3. This section describes the limitations of see and avoid, summarising some of the numerous safety articles, books and investigation reports readily available to pilots. This, however, is not a full or in-depth review of the factors involved, so readers are referred to the various resources detailed at the end of the Citations section. The principal resource reviewed was the ATSB research report, Limitations of the See-and-Avoid Principle, reprinted in November 2004.

4.3.4. Sight is a primary means by which a person receives information, but there are a number of naturally occurring limitations with human eyesight that should be understood by anyone who relies on their sight to accomplish safety-critical tasks.

4.3.5. The normal field of vision for the human eye is about 190°, but this starts to reduce after about age 35 years. Also with age the lens in the eye starts to harden, making it more difficult for the lens to change shape in order to focus. Behind the lens are the light-sensitive cells of the retina, with 2 kinds of receptor – rods and cones. The cones are for direct vision in good light and are located at the fovea, or central part of the retina. They also provide colour. Farther out from the centre of the retina, the periphery, are the rods, which have no colour sensitivity and are used for dim light conditions.

4.3.6. The cones and rods work in concert. The **peripheral vision** detects rapid movement, while the central or **foveal vision** provides the colour and slow movement detail. In daylight, visual acuity or sharpness is greatest at the fovea, but at night the peripheral vision is best. The arc of foveal vision is narrow, so a pilot needs to scan around the sky to increase the probability of detecting an aircraft early. Pilots may therefore have difficulty detecting aircraft that are positioned near the corner of their fields of view, a limitation called **tunnel vision.** A similar challenge exists for motor vehicle drivers.

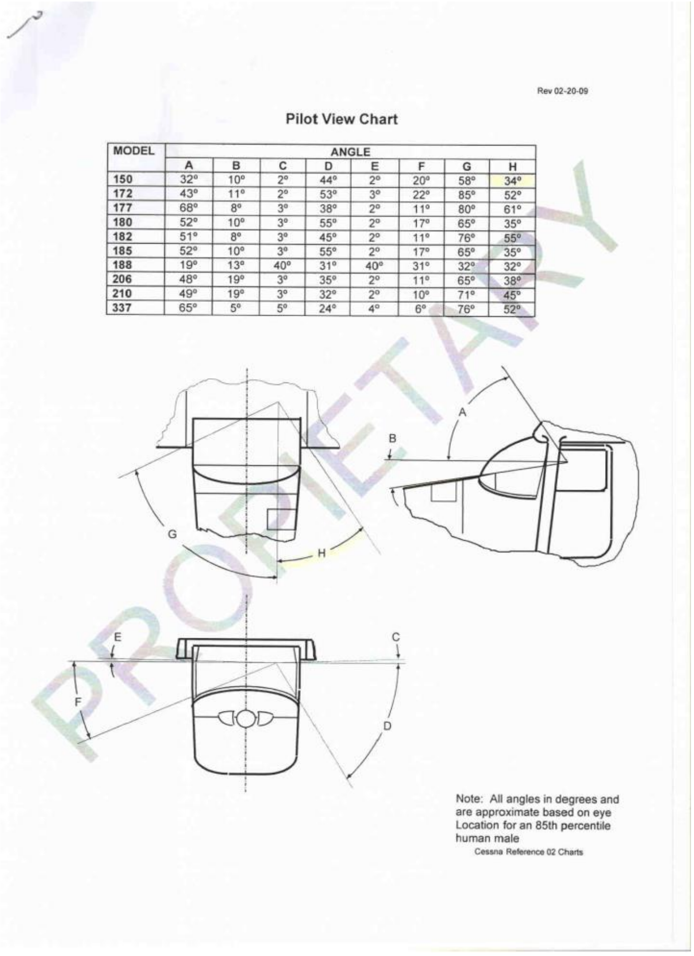
4.3.7. The muscles that control eye movement also provide for convergence of the eyes to give depth perception. However, as a pilot scans the horizon, the eye jumps from one focal point to another. This is called saccades and can cause gaps in the visual field, especially at longer distances. The human eye has a natural focal length estimated to be around 50-55 centimetres. As the pilot scans outside the aircraft, and if there are no visual cues to focus on, the eye will tend to return to the natural focal length. This effect is called **empty field myopia** and reduces the probability of detecting a distant object – especially when there are few objects available in the distance to draw the focal point out. Objects at or near the natural focal length can also trap the eye into focusing just in front of the pilot. Termed the **mandelbaum effect**, objects like a dirty windscreen can draw in the focus, causing a more distant object to be missed.

4.3.8. The eye also has a blind spot where the optic nerve exits the eyeball. This is not normally a problem as the image on the blind spot is visible to the second eye – binocular vision. However, if a pilot's view is restricted, for example by a part of the aircraft like a window frame, an aircraft behind it may go undetected.

The aircraft

4.3.9. A pilot's field of view can be limited by the design of the aircraft. Door frames, wings, the instrument panel, the floor and the fuselage behind the pilot can all hide an approaching aircraft. A pilot sitting in the left seat may have a good view out to the left, but difficulty in seeing out to the right.

4.3.10. Figure 8 shows a pilot's field-of-view chart for the Cessna range of single-engine, high-wing aeroplanes. The figures are based on the eye location for an "85th percentile human male". In other words the data should be accurate for 85% of males, but would vary for persons away from this average. The figures for the model 150 are representative of the available visibility for the Cessna 152.



Rev 02-20-09

Pilot View Chart

MODEL	ANGLE							
	A	B	C	D	E	F	G	H
150	32°	10°	2°	44°	2°	20°	58°	34°
172	43°	11°	2°	53°	3°	22°	85°	52°
177	68°	8°	3°	38°	2°	11°	80°	61°
180	52°	10°	3°	55°	2°	17°	65°	35°
182	51°	8°	3°	45°	2°	11°	76°	55°
185	52°	10°	3°	55°	2°	17°	65°	35°
188	19°	13°	40°	31°	40°	31°	32°	32°
206	48°	19°	3°	35°	2°	11°	65°	38°
210	49°	19°	3°	32°	2°	10°	71°	45°
337	65°	5°	5°	24°	4°	6°	76°	52°

Note: All angles in degrees and are approximate based on eye Location for an 85th percentile human male

Cessna Reference 02 Charts

Figure 8
Cessna pilot view chart
(Courtesy of Cessna Aircraft Company)

4.3.11. Figure 9 and Figure 10 show the visibility available for the average pilot when positioned in the left and right seats. Using the radar data to determine the relative bearings and height differences between the 2 aeroplanes at given times, the approximate locations of the opposing aeroplanes as they approached each other for the final 30 seconds have been plotted and shown in Figure 9 for both students seated in the left seat, and Figure 10 for the instructor seated in the right seat.

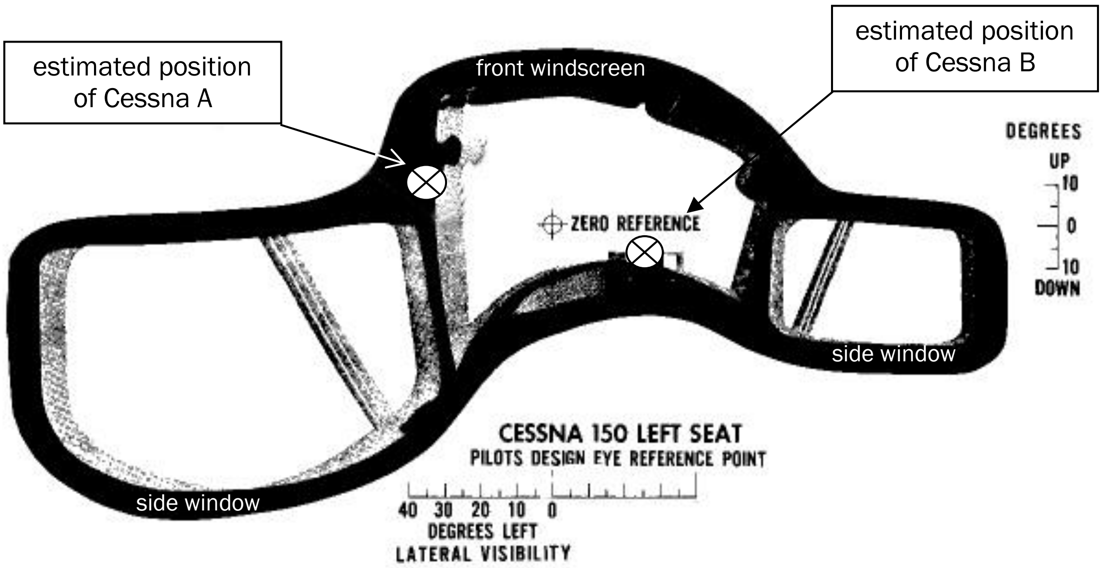


Figure 9
Visibility diagram – left seat
(Courtesy of the ATSB)

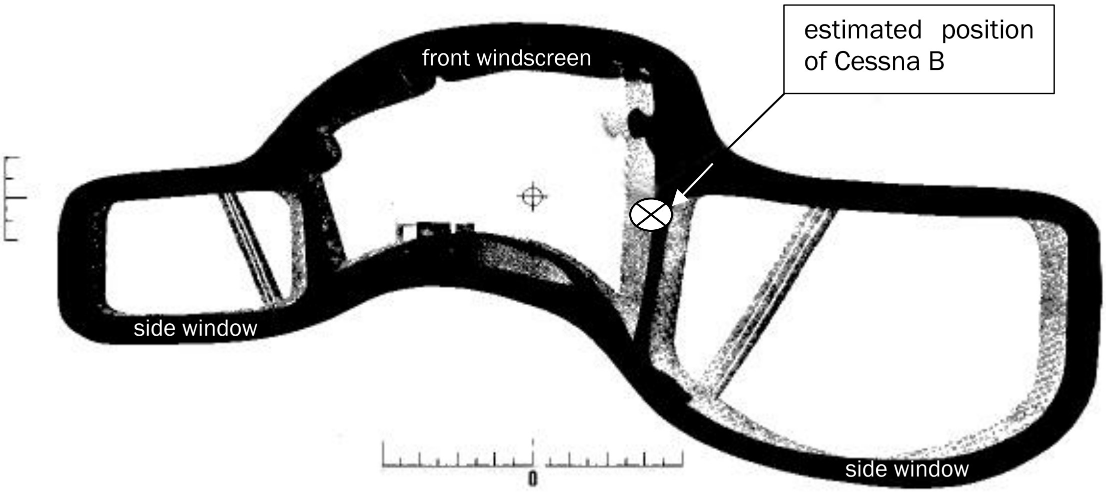


Figure 10
Visibility diagram – right seat
(Courtesy of the ATSB)

4.3.12. According to the pilot field-of-view charts, the opposing aeroplane should have been visible to the 3 pilots to some extent. Student A, seated in the left seat of Cessna A, would have had the most difficulty of the 3 pilots in seeing the other aeroplane. Cessna B should have been visible in the main windscreen but, as it was climbing towards Cessna A, it would have been low down in the front windscreen and about in line with the top of the instrument panel. Student A would have needed to stretch up to get a clear view of Cessna B as it approached.

4.3.13. For student B seated in the left seat of Cessna B, the other aeroplane should have appeared about midway up the main windscreen, but may have been blocked or partially blocked by the framing between the left door and front windscreen.

4.3.14. For the instructor seated in the right seat of Cessna A, the other aeroplane should have appeared about midway up the main windscreen and towards the right side, where it may have been partially blocked by the framing between the right door and the front windscreen. The window framing could have created blind spots and obstructed the pilots' views. That is why pilots are taught to be aware of blind spots and move their heads about to look around the obstacles. And, if required, an aeroplane can be manoeuvred to facilitate an effective lookout.

4.3.15. Another challenge for a pilot in locating other aircraft can be their **conspicuity**; that is, their contrast with the environment or background. The size and profile (aspect) of an aircraft are relevant and will be different depending on whether it is seen head-on, side-on or while it is turning. The contrast between the colour of an aircraft and its background may vary owing to atmospheric effects, for example the angle of the sun, haze, broken light and shadows. The background terrain and vegetation can also act to camouflage an aircraft under some conditions.

4.3.16. Visibility studies referred to in the ATSB report noted that no one particular paint scheme was found to be more advantageous owing to the wide variety of environmental conditions. For example, light-coloured aircraft were harder to detect in bright conditions and, equally, darker-coloured aircraft in dull conditions or with dark vegetation behind them. The ATSB report noted that “fluorescent paint has been suggested as a solution to the contrast problem”. Several trials had found no benefit and against a typical, light background, the increased luminance of the aircraft would only serve to reduce the contrast. However, in the intervening 20-plus years high-visibility paints and equipment have improved, so there may be some benefit in revisiting the utility of fluorescent-type paints for aircraft use.

4.3.17. According to the operator's standard practice for its pilots and what was found post-accident, the red anti-collision lights and landing lights in both aeroplanes would have likely been on as they approached each other. These lights would have increased the conspicuity of an aircraft in dark or dull conditions, but in the bright conditions prevailing at the time of the accident they would not have been very effective in attracting the attention of the pilots. The use of high-intensity flashing lights or strobe lights can help to enhance the all-round conspicuity of an aircraft in medium and low light conditions. The Commission has recommended that the Director of the CAA consider more modern, brighter lights on aircraft to increase their conspicuity during daylight operations.

4.3.18. There was nothing in the background to degrade the conspicuity of Cessna A for student B, because it was above the horizon. The presence of scattered cloud at 2500 feet should have helped him to focus well into the distance. By comparison, Cessna B was slightly below the horizon for the pilots in Cessna A and therefore more likely to blend in with the ground features, including Palmerston North in the distance beyond Feilding Aerodrome. The sun would have been either behind or well to the side of the pilots and should not have impeded their ability to see each other.

4.3.19. The eye is tuned to detect movement firstly, then to focus on the object to identify it. Two aircraft approaching each other on steady headings maintain a constant relative bearing to each other. They therefore provide little or no relative movement and may appear to be motionless. This is dangerous, as the apparent size of an approaching object changes little until it gets much closer, when it suddenly starts to loom much larger and attracts a pilot's attention. This is known as the **blossom (or bloom) effect** because the previously undetected object suddenly blooms into a large object that fills the field of view. The faster the closing speeds, the less time there is for a pilot to react to this threat.

4.3.20. An analysis of the radar data showed that for the last 30 seconds as the 2 aeroplanes approached each other, they were both maintaining constant tracks. As a result Cessna B remained about 25° off to the right of the nose of Cessna A and never more than 3° below the horizon during this time. Cessna A remained about 35°to the left of the nose of Cessna B and not more than 3° above the horizon (see Figure 11).

4.3.21. The pilots of both aeroplanes should therefore have been able to see the other. However, with a closing speed calculated to be between 130 and 145 knots (about 240-270 km per hour), the opposing aeroplane would have initially appeared small and its apparent size would not have changed appreciably. The constant bearing and lack of relative movement as they closed on each other during the last 30 seconds meant that there was little to attract the pilots' attention towards the other aeroplane.

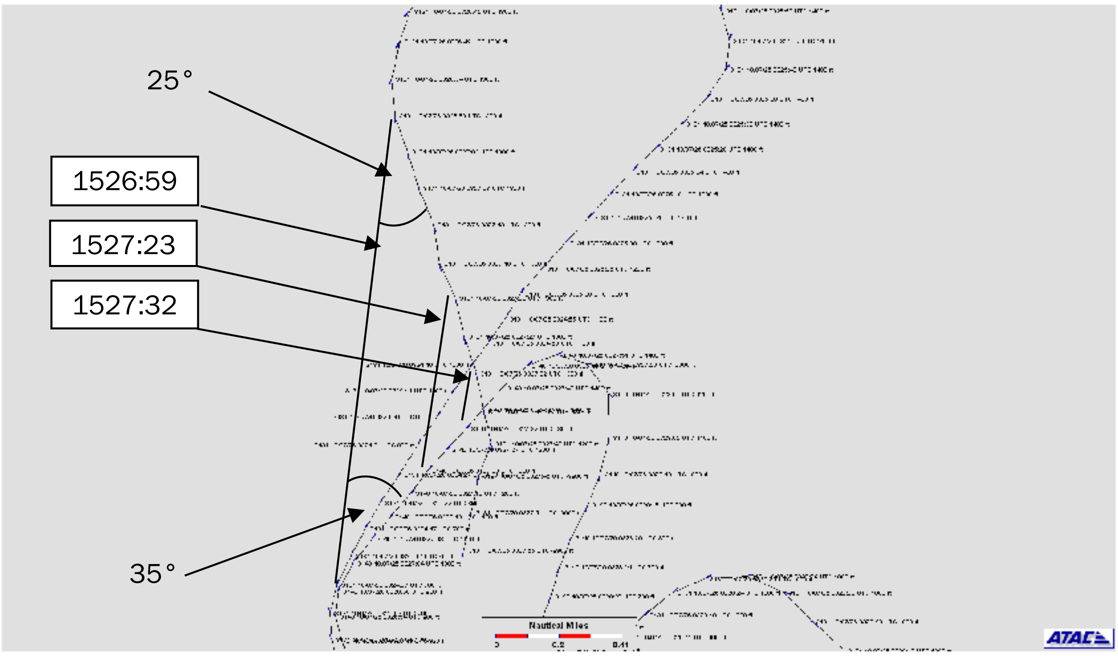


Figure 11
Relative bearing plot
(Courtesy of Airways New Zealand)

Findings

Both Cessna A and Cessna B should have been visible to the pilots of the other aeroplane as they approached each other on a collision course.

There are a number of natural limitations with human eyesight that can significantly reduce its effectiveness for detecting aircraft in time to take avoiding action. Some of these factors probably contributed to the pilots of these 2 aeroplanes not seeing the other aeroplane in time to avoid the collision.

Aircraft cockpits by necessity will limit the pilots' fields of vision outside the aircraft, which pilots are taught to counter using suitable scanning techniques. It is possible that the available field of vision for the 2 aeroplanes, combined with the closing angle, also contributed to the pilots not seeing the other aeroplane in time to prevent the collision.

The concept of see and avoid is an effective and important process for the safety of aircraft operations. It does, however, have limitations that can be mitigated by pilots knowing those limitations and employing good lookout techniques.

The use of high-intensity anti-collision lighting, and possibly high-visibility paints, can improve the conspicuity of an aircraft in most daylight conditions, promoting earlier detection.

Listening for and avoiding other aircraft

4.3.22. Without detracting from the need for pilots to keep effective lookouts, it is clear that using only see and avoid is no guarantee of avoiding a collision. Talking and listening on the other hand help pilots to build a mental understanding (picture) of where other aircraft are and the danger they pose. Even information about the presence of other aircraft that are not equipped with radios can be shared among aircraft that are so equipped.

4.3.23. Reaction times for pilots may vary for a number of reasons, including age, experience and alertness. In 1983 the FAA produced an advisory circular that included the results of a study by the US Navy into mid-air collisions and pilot reaction times. The study concluded that from starting to detect an object it could take up to 12.5 seconds for a pilot to recognise and react to a possible collision. The FAA and the various arms of the US military continue to use the 12.5-second reference today. The 12.5-second reaction and avoidance timeframe is broken down as follows:

Action	Reaction time
See object	0.1 seconds
Recognise aircraft	1.0 seconds
Become aware of collision	5.0 seconds
Decision on action	4.0 seconds
Muscular reaction	0.4 seconds
Aircraft lag time	2.0 seconds
Total	**12.5 seconds**

4.3.24. Reaction times can be significantly reduced if pilots are aware of aircraft that may come into conflict, or conflicting aircraft are sufficiently close to demand immediate action to avoid collision. A report by the Royal Australian Air Force Institute of Aviation Medicine determined that it took 5.5 seconds to detect such an aircraft and react. The 5.5 seconds were broken down as follows:

Process	Time
Detect, visualise, recognise	1.0 seconds
Decide what to do	2.0 seconds
Initiate action	2.5 seconds
Total	**5.5 seconds**

4.3.25. In both the Paraparaumu and the New Plymouth occurrences, the pilots made the required radio calls announcing their positions and intentions. At Paraparaumu, none of the pilots requested the other over the radio to confirm their position, so that they could ensure separation. The same circumstance applied to this accident. The pilots in both aeroplanes made appropriate radio calls that should have alerted the other(s) that an aircraft potentially needed to be seen and avoided.

4.3.26. These occurrences identify the critical need not only to make clear, concise and correct radio transmissions, but also to actively listen to the transmissions from other aircraft and understand their implications. This allows pilots to focus their efforts on locating and avoiding other aircraft. If there is any doubt, pilots should not hesitate to challenge the opposing aircraft and clarify the information, rather than continue into an increasingly hazardous situation.

4.3.27. Student B recalled hearing radio transmissions from other aircraft, including the agricultural aeroplane taking off. A number of other radio transmissions were made around this time, including the co-ordination going on between Cessna A and Cessna C and the lining-up, take-off and departure calls from Cessna B, but the total radio traffic and aircraft movements were not high. Student B should have heard, but did not recall hearing, the joining call made from Cessna A, but was aware that it was performing overhead joins. Had he heard that call he would have had between 35 and 95 seconds to respond to that call and look for the aeroplane.

4.3.28. It could not be determined where in the crosswind sector student B made his “crosswind” call. If that call from Cessna B had been made after the turn was completed, that would have left between 15 and 25 seconds only for the pilots in Cessna A to hear that call, recognise that Cessna B would be a threat to their aircraft, search for Cessna B and take avoiding action. The initial cue to the pilots of Cessna A that Cessna B was possibly going to be a threat was the “lining up” and “rolling” calls that student B made. If for some reason the pilots of Cessna A did not hear or comprehend those calls, 15 to 25 seconds was all they had.

4.3.29. So why was it that in this accident, and in the Paraparaumu and New Plymouth occurrences, neither the student pilots nor the instructors accurately comprehended what was happening around them?

4.3.30. Other human factors that affect a pilot’s ability to detect a conflicting aircraft include pilot experience, fatigue, stress and workload. Fatigue was not identified as a factor in this or the other 2 occurrences.

4.3.31. A student learning to fly or undertake a new exercise will be focused on flying the aircraft and have little spare capacity to maintain an effective lookout. Similarly an instructor teaching an exercise has the dual role of keeping the aircraft safe and maximising the learning opportunities for the student. As a student becomes more experienced and comfortable in the aircraft, they will be able to devote a greater percentage of their attention to listening and looking out to detect potential conflicts.

4.3.32. Experience and training help pilots to develop both the capacity and the ability to identify potential collisions and take appropriate avoiding action. Properly trained, experienced pilots have more time to scan for threats, are better able to decipher radio calls and know where and what to look for. Their reactions also become more automatic, so reaction times reduce.

4.3.33. Student A was the least familiar with the area and was undergoing instruction on the joining procedure, which was an exercise that she had flown before, but not at Feilding. Of the 2 pilots in Cessna A, student A was also less familiar with hearing position reports made by pilots around the local area and may have found them difficult to understand. She could therefore have been focusing on flying the aeroplane accurately and relying on the instructor to identify any lapses, including any failure to respond to radio calls that might be relevant.

4.3.34. Air traffic controllers and pilots spoken to during this inquiry indicated that under unusual circumstances or times of added stress, it could be harder to understand the radio transmissions of those for whom English was a second language. The Commission makes the observation that the reverse could also apply; that those for whom English is a first language can have a tendency to talk more quickly and use less formal language when under stress, making it more difficult for foreign students to understand.

4.3.35. The instructor was not inexperienced, having flown 1566 hours and spent about 3.5 years as an instructor. Of the 3 pilots involved she was the most familiar with the local airspace and operations. In addition to monitoring student A’s performance, she was responsible as the pilot-in-command for ensuring the safety of the flight. With her flying experience and having worked with foreign students for the preceding 4 years, she should have had little difficulty in understanding the transmissions from Cessna B as it took off and departed, and recognised the potential threat that it posed to Cessna A approaching the circuit.

4.3.36. There was no obvious manoeuvring of Cessna A or any clarifying radio transmissions. That could be explained by her prioritising her attention on the student. The instructor was seated to the right of the student, so monitoring her actions would have drawn the instructor’s gaze away from Cessna B approaching from the forward-right of the aeroplane.

4.3.37. Student B had been flying from Feilding for nearly 4 months and had accrued nearly 20 flying hours during this time, including 12 hours flying solo. He was therefore familiar with the area and should have understood that the aircraft joining from the north could come into conflict as he vacated to the north-east. Having completed the after-take-off actions and established in the climb, there should have been no impediment to establishing a good lookout and locating Cessna A as it approached from his forward left side – the side on which he was seated.

However, the radar data indicated that a few seconds before the collision he levelled his aeroplane at 1300 feet. His attention may therefore have been diverted inside the aeroplane at this critical time, as he adjusted the engine power setting and trimmed the aeroplane for level flight.

4.3.38. The radar data also showed that each time after vacating the circuit, Cessna A flew to the north about 3 nautical miles before turning back towards the aerodrome. At 3 nautical miles, Cessna A was only just clear of the circuit area. The instructor probably did this to complete the maximum number of joining procedures in the course of the flight. By remaining on the same radio frequency throughout, the 2 pilots on board Cessna A should have, at least collectively, maintained a good awareness of the traffic, excluding any non-radio-equipped aircraft, in the local area.

4.3.39. The normal practice to follow when joining an aerodrome was to listen on the designated frequency first, to get an idea of the traffic in the local area and start developing a mental picture of what to expect, such as how many aircraft could be in the circuit and which runway they were using. The pilot would then make a joining call, normally between 5 and 10 nautical miles from the aerodrome. This should give plenty of time to build on the mental picture and gain good situational awareness.

4.3.40. However, Cessna A was only just clearing the circuit area by 3 nautical miles. The instructor was probably compressing the procedure into the time available to teach the student all the facets of the joining procedure. This would have increased the workloads of both pilots. It also provided less time for the pilots to locate visually any other aircraft before entering the circuit area.

4.3.41. It is easy to see that for an instructor engaged in dual training, the prime responsibility must be for them to maintain command of the aircraft and ensure its safety. It is also easy to see that an instructor could become consumed by the task of instructing the student pilot, to the detriment of the effective command of their aeroplane.

4.3.42. One would imagine that the more experienced an instructor becomes, the easier this task should be. However, as overseas research and the Paraparaumu and New Plymouth occurrences showed, even very experienced instructors can appear for some reason to not comprehend totally what is happening around their aircraft. This would seem to be a safety issue that requires some work by the industry. The Commission recommends that the Director of the CAA address this safety issue.

Findings

Radio communication between aircraft fitted with radio equipment is an essential process that should precede and then assist pilots to see and avoid other aircraft.

Pilots need to **make** clear, concise and timely radio transmissions about **their** locations and intentions so that other pilots can build mental pictures of the other traffic around them and how it is going to affect their own plans. The radio transmissions made by both aircraft before the collision achieved that initial objective.

Pilots need to **listen** to radio transmissions from **other** aircraft and use that information to build mental pictures of the other traffic around them and how it is going to affect their own plans. It appears that the pilots of both aircraft involved in this collision did not achieve this.

The first priority of a pilot-in-command must be to ensure the safety of their aircraft, before engaging in other tasks.

Standard overhead join

4.3.43. The standard overhead joining procedure is an effective means of joining an aerodrome circuit pattern and landing when there is no air traffic service or special joining instructions to direct a pilot. The procedure is especially applicable to pilots joining unfamiliar aerodromes, allowing them to assess the locations of other traffic, possible hazards and the best runway to approach and on which to land.

4.3.44. A key benefit of the standard overhead join, like the standard circuit pattern, is that by following a pattern and making radio calls at designated positions, pilots are better able to build mental pictures of where other aircraft are located and their intentions. This in turn helps direct the pilots' lookout to locate aircraft that may possibly come into conflict.

4.3.45. The standard overhead joining procedure, however, implies standard conditions. At Feilding, the standard procedure of flying overhead the aerodrome 500 feet above the 1200-foot circuit altitude[16] could not be done without infringing on controlled airspace. The option of obtaining an ATC clearance in order to fly a copy-book standard join was impractical for radio management and operational reasons, particularly for less experienced pilots. As a result, the usual vertical separation between joining aircraft and circuit traffic was reduced from 500 feet to about 300 feet.

4.3.46. The 300-foot separation provided fewer margins for error. Student pilots, of whom there were many at Feilding, would not be expected to maintain a specific altitude as accurately as an experienced pilot. They would not have wanted to climb into controlled airspace by mistake and be admonished by their instructors, ATC or both. It was therefore common to expect aircraft to join overhead at 1400 feet to provide a small buffer. This is what Cessna A did on the day of the collision. However, when the aeroplane descended to 1300 feet while making its turn, the margin above the circuit traffic was reduced to only 100 feet.

4.3.47. Radar recordings showed that on 26 July 2010, after completing the second circuit join and touch-and-go landing, Cessna A climbed to 1400 feet as it vacated the immediate circuit area. The aircraft then turned left towards Feilding township and the aerodrome. After 2 previous right turns, the left turn back to the aerodrome was possibly the instructor intending to show student A how to rejoin the circuit from a different angle. It was during this turn that the aircraft descended to 1300 feet. It could not be established if this was intentional or inadvertent. At the same time Cessna B climbed to 1300 feet and it was at this altitude that the 2 aeroplanes collided. The setting of 1019 hPa on the altimeter of Cessna B was consistent with the pressures being reported at Ohakea and Palmerston North Aerodromes and Feilding Aerodrome being located some 50 to 65 feet lower. Therefore, while there are some tolerances regarding the accuracy of the radar data, the 1300-foot figure can be assumed to be reasonably accurate.

4.3.48. The standard overhead join was not promoted by the aerodrome operator for the reasons given above, but it was a skill that had to be practised by students as part of their training. The reduced separation between an aircraft in the circuit and those performing standard overhead joins increased the risk of a mid-air collision in the area, and probably contributed to this collision.

4.3.49. This does not mean that the standard overhead rejoin should not happen there. It just means that students, and particularly their instructors, need to be extra vigilant and aware of the increased risk. (See section 7, Safety actions.)

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[16] 1000 feet above ground level.

Findings

The standard overhead rejoin procedure could not be accurately flown by aircraft arriving at Feilding because airspace limitations above the aerodrome prevented aircraft flying overhead 500 feet above the circuit height.

The reduced height separation between aircraft joining overhead Feilding Aerodrome and aircraft in the circuit below increased the risk of mid-air collisions in the area, and probably contributed to this mid-air collision.

Technology as a fix

4.3.50. Technology, for example ACASs such as TCAS, can give an indication of other traffic in the area and direct a pilot to take avoiding action if the threat is serious enough. This system has proved very successful and, along with the ATC Short Term Conflict Alert function, is credited with preventing collisions overseas and in New Zealand.

4.3.51. However, an ACAS is a specialised piece of equipment. It can only "see" aircraft that have operating transponders, and can only direct avoiding action if the other aircraft are transmitting altitude information. Aircraft operating in controlled airspace are required to have encoding altimeters, and ACASs are required for large and medium aircraft. Less capable and less expensive ACASs are available for fitting to general aviation aircraft.

4.3.52. Notwithstanding the ability of technology to detect a threat, the first action when an ACAS gives a "traffic advisory" is for the pilot(s) to look for the traffic. In other words, even with this advanced equipment, see and avoid remains an essential part of the process. To minimise nuisance advisories, it is usual to inhibit the capability of this equipment when approaching busy aerodromes. Consequently the usefulness of such equipment around an aerodrome with a high percentage of training activity could be limited.

4.3.53. Some aircraft owners, flying training organisations in New Zealand and the 2 US studies indicate that new technology does not necessarily improve safety in all areas. Because of the tendency for pilots to have their heads down, looking at the instruments regardless of the external conditions, it may actually degrade see and avoid as a last defence. For an ACAS to be fully effective, all aircraft must be fitted with transponders and encoding altimeters. At least one of the aircraft in a potential collision pair must also have an ACAS, because it requires only one aircraft to take the appropriate action to avoid a collision. The mandatory fitting of ACASs to large and medium aircraft is eminently sensible.

4.3.54. At an aerodrome like Feilding, some aircraft are not even equipped with radios. Making the jump from the current standard to one where all aircraft are required to be fitted with ACASs would require a significant philosophical change in approach to training and general aviation operations, as well as not insignificant cost. Justifying the idea that such a change is needed now would require a cost-benefit analysis. As mentioned earlier in this report, mid-air collisions are relatively rare. Without downplaying the tragic consequences of this accident, the current situation works most of the time. Pilots do see and avoid other aircraft more often than not. No doubt with time, as ageing aircraft are replaced by new aircraft with this technology fitted, there will be a natural shift to using that technology. This has been the case with many other enhancements made to aircraft over time. Meanwhile there are ways in which current operating practices can be improved (refer to the recommendations made and safety lessons learned in this report) and the first focus should be on making these improvements, now.

Finding

Technological enhancements used to help prevent collisions involving medium and large aircraft would not currently be feasible at aerodromes like Feilding owing to the size and complexity of small aircraft operations there.

5. Findings

5.1. Feilding Aerodrome and the airspace around it, and the variety of aircraft that used and transited over the aerodrome, could at times create a busy and complex environment for student pilots and instructors to deal with. However, at the time of the accident the aerodrome was not busy and there were no unique challenges identified that might have contributed to the collision.

5.2. The nosewheel of Cessna B struck and severed part of Cessna A's wing, rendering Cessna A incontrollable, causing it to crash.

5.3. The nosewheel and engine of Cessna B were forced back, damaging the engine carburettor and causing the engine to stop. However, the aeroplane was still controllable, allowing the pilot to make a successful emergency landing.

5.4. The communication equipment in both aeroplanes was working and there was no evidence that a technical failure contributed to the collision.

5.5. Both Cessna A and Cessna B should have been visible to the pilots of the other aeroplane as they approached each other on a collision course.

5.6. There are a number of natural limitations with human eyesight that can significantly reduce its effectiveness for detecting aircraft in time to take avoiding action. Some of these factors probably contributed to the pilots of these 2 aeroplanes not seeing the other aeroplane in time to avoid the collision.

5.7. Aircraft cockpits by necessity will limit the pilots' fields of vision outside the aircraft, which pilots are taught to counter using suitable scanning techniques. It is possible that the available field of vision in the 2 aeroplanes, combined with the closing angle, also contributed to the pilots not seeing the other aeroplane in time to prevent the collision.

5.8. The concept of see and avoid is an effective and important process for the safety of aircraft operations. It does, however, have limitations that can be mitigated by pilots knowing those limitations and employing good lookout techniques.

5.9. The use of high-intensity anti-collision lighting, and possibly high-visibility paints, can improve the conspicuity of an aircraft in most daytime conditions, promoting earlier detection.

5.10. Radio communication between aircraft fitted with radio equipment is an essential process that should precede and then assist pilots to see and avoid other aircraft.

5.11. Pilots need to **make** clear, concise and timely radio transmissions about **their** locations and intentions so that other pilots can build mental pictures of the other traffic around them and how it is going to affect their own plans. The radio transmissions made by both aircraft before the collision achieved that initial objective.

5.12. Pilots need to **listen** to radio transmissions from **other** aircraft and use that information to build mental pictures of the other traffic around them and how it is going to affect their own plans. It appears that the pilots of both aircraft involved in this collision did not achieve this.

5.13. The first priority of a pilot-in-command must be to ensure the safety of their aircraft, before engaging in other tasks.

5.14. The standard overhead rejoin procedure could not be accurately flown by aircraft arriving at Feilding because airspace limitations above the aerodrome prevented aircraft flying overhead 500 feet above the circuit height.

5.15. The reduced height separation between aircraft joining overhead Feilding Aerodrome and aircraft in the circuit below increased the risk of mid-air collisions in the area, and probably contributed to this mid-air collision.

5.16. Technological enhancements used to help prevent collisions involving medium and large aircraft would not currently be feasible at aerodromes like Feilding owing to the size and complexity of small aircraft operations there.

6. Key lessons

6.1. The first priority for an instructor, as the pilot-in-command, is to maintain command of their aircraft and ensure its safety before attending to the training needs of the student pilot.

6.2. Pilots must make clear, concise, accurate and timely radio transmissions, and they need to listen actively to the transmissions of others to help build accurate pictures of what is occurring around them.

6.3. Pilots need to maintain a good lookout and ensure that their scans cater for any blind spots in the cockpit, either by moving their heads to look around any obstructions or by manoeuvring their aircraft.

6.4. Pilots need to be aware of the limitations of the human eye and understand how this can affect their ability to see and avoid other aircraft.

7. Safety actions

General

7.1. The Commission classifies safety actions by 2 types:

(a) safety actions taken by the regulator or an operator to address safety issues identified by the Commission that would otherwise have resulted in the Commission issuing a recommendation

(b) safety actions taken by the regulator or an operator to address other safety issues that would not normally have resulted in the Commission issuing a safety recommendation.

Safety actions addressing safety issues identified during an inquiry

7.2. On 7 April 2011, the operator of Feilding Aerodrome issued amended landing chart information and "preferred VFR arrival and departure" procedures for runway 10 and runway 28 at Feilding. The aerodrome circuit altitude was lowered to 1100 feet and a note was added advising that: "**Pilots should avoid using overhead rejoins at Feilding Aerodrome**" (emphasis in original). If pilots did not have situation awareness of circuit traffic, they could then continue for an overhead rejoin.

The departure procedures included the instruction to climb and maintain 1100 feet until well clear of the circuit area.

7.3. In November 2010 the CAA published an article in its quarterly magazine *Vector* titled "**Standard,** but is it Safest?". The article discussed the use of standardised procedures, including the standard overhead join, and when these should and should not be used.

7.4. On 15 July 2011, the CAA advised that its Aeronautical Services Unit, in conjunction with CAA aviation safety advisers, was working with a number of aerodrome operators to address specific issues identified with local procedures. This included the MOU for the nearby Palmerston North Aerodrome users' group, which was being reviewed to ensure that it met CAA requirements.

7.5. In February 2012 the CAA issued a Good Aviation Practice booklet titled "Plane Talking – A Guide to Good Radio Use". The booklet complemented a series of 31 seminars held around the country between March and May 2012 to help educate pilots on the use of radio. The booklet and seminars were available to all pilots and training organisations.

7.6. On 4 June 2012, the CAA informed the Commission of a number of additional safety actions completed or currently underway. These actions included:

- The ongoing oversight of non-certificated aerodromes using an inspection regime based on potential risk.
- On 1 April 2012 the introduction of a more focussed risk assessment based approach to the conduct of surveillance and monitoring activity.
- Development of a 7-point runway, airspace and aerodrome safety programme and the ongoing addressing of issues within this programme.
- Working with individual aerodrome operators to address circuit risks and the development of Advisory Circular guidance material on aerodrome user groups.
- The development of a tool to assist aerodrome operators in assessing aerodrome complexity and identify remedial action.
- Ongoing deployment of various safety promotion and education programmes, and providing assistance to aerodrome operators and user groups.

8. Recommendations

General

8.1. The Commission may issue, or give notice of, recommendations to any person or organisation that it considers the most appropriate to address the identified safety issues, depending on whether these safety issues are applicable to a single operator only or to the wider transport sector. In this case, recommendations have been issued to the Director of Civil Aviation.

8.2. In the interests of transport safety it is important that these recommendations are implemented without delay to help prevent similar accidents or incidents occurring in the future.

Recommendations

8.3. On 12 February 2013, the Commission made the following recommendations to the Director of Civil Aviation.

8.3.1. The Paraparaumu and Feilding mid-air collisions both involved instructors who, because of their experience and training, should have been the most capable of the pilots to be able to recognise the potential for a mid-air collision and take avoiding action. It appears that in these cases the instructors might have been focusing more on instructing or examining the student pilots and less on ensuring the safety of their aircraft.

The Commission recommends that the Director inform flight instructors at all levels of the findings of this report, and in particular that their first responsibility is the safety of the aircraft they are commanding, before attending to the needs of their student pilots. Further, instructors are reminded of their responsibility for ensuring that student pilots are informed and competent to listen for, see and avoid other aircraft before allowing them to fly solo. (Recommendation 029/12)

8.3.2. The Paraparaumu and Feilding mid-air collisions have shown that despite pilots making appropriate radio transmissions, they have failed to listen actively and respond appropriately to the transmissions of others and take action to avoid collisions.

The Commission also notes that limitations with the concept of see and avoid probably contributed to the Paraparaumu and Feilding mid-air collisions as well as the near miss above New Plymouth.

The Commission recommends that the Director of Civil Aviation use the lessons from this report to educate pilots at all levels of the aviation industry, and in particular flight training establishments, of:

- how important the concept of see and avoid is for detecting and avoiding other aircraft
- the limitations of the concept of see and avoid
- the importance of making clear and concise radio transmissions to warn other aircraft of your location and intentions, and the importance of listening to radio transmissions from other aircraft to help build an accurate mental picture of the situation around you. (Recommendation 030/12)

8.3.3 Various aircraft paint schemes have shown to have little benefit in improving the conspicuity of aircraft for the wide range of weather, environmental and geographical conditions likely to be encountered. Similarly the current minimum aircraft lighting requirements are not always effective in attracting the attention of pilots in bright conditions. However, more modern, high-intensity strobe lighting and new high-visibility paints may increase the ability of an aircraft to be detected in most lighting conditions and could improve the reliability of see and avoid as a primary means of preventing mid-air collisions.

The Commission recommends that the Director of Civil Aviation initiate a review of aircraft anti-collision lighting systems, including the use of high-visibility paints, to determine whether there are systems that can increase the visibility of aircraft; and if such systems are found to exist with demonstrable safety benefits, start action to promote, encourage or mandate their application in the New Zealand civil aviation system. (Recommendation 031/12)

On 12 March 2013, the Director of Civil Aviation Authority replied:

> a) *Recommendations 029/12 and 030/12*
> *As provided in our letter of 23 August 2012, the CAA considers the level of its current activity to address the issues is sufficient, given the competing priorities. Accordingly, the CAA considers that both recommendations have been fully addressed.*
>
> b) *Recommendation 031/12*
> *The CAA confirms the recommendation is being implemented. A review of anit-collision lighting systems and high visibility paint use is currently being assessed by the Operations and Airworthiness Group. An implementation ate has yet to be finalised.*

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