Australian Government

Australian Transport Safety Bureau

Piper PA-23-250 Aztec, VH-WAC
1 km WSW Mareeba Aerodrome, Qld.
1 October 2003

INVESTIGATION REPORT

BO/200304091

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PREFACE

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

In terms of aviation, the ATSB is responsible for investigating accidents, and other safety occurrences involving civil aircraft operations in Australia, as well as participating in overseas investigations of accidents and serious incidents involving Australian registered aircraft. The ATSB also conducts investigations and studies of the aviation system to identify underlying factors and trends that have the potential to adversely affect safety. A primary concern is the safety of commercial air transport, with particular regard to fare-paying passenger operations.

The ATSB performs its aviation functions in accordance with the provisions of the *Transport Safety Investigation Act 2003*, Part 4. The Act (Part 1, Section 7) states that the main object of the Act is to improve transport safety by providing for the reporting of transport safety matters, the independent investigation into transport accidents and other incidents that may affect transport safety, the making of safety action statements and safety recommendations that draw on the result of those investigations and the publication of the results of those investigations in the interest of transport safety. As with equivalent overseas organisations, the ATSB has no power to implement its recommendations.

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

1 FACTUAL INFORMATION

1.1 History of the flight

The pilot, his wife and three children were conducting a private flight from Mareeba, Queensland to Roma, Queensland in the Piper PA-23-250 Aztec aircraft, registered VH-WAC. Prior to departure, the pilot was observed conducting pre-flight activities, including an aircraft inspection, refuelling the aircraft, and engine run-ups.

A witness, located in a shed north of the eastern end of the runway, reported that he briefly saw the aircraft early in its take-off roll on runway 28, at which time the engines sounded normal. No witness was in a position to see the point on the runway at which the aircraft became airborne. Another witness, facing south in the cab of stationary truck, on a road about 90 m beyond the end of runway 28, and about 150 m north of the extended runway centreline, saw the aircraft fly over that road. He thought the aircraft was at an unusually high nose-up attitude, and was between 100 and 150 ft above ground level (AGL). He reported that the landing gear was retracted. He then saw the aircraft start to bank to the left and the nose-up attitude reduce to a more reasonable angle.

Another witness, located about 2 km north-east of the departure end of the runway, watched the aircraft from shortly after take-off until it reached a left bank angle of about 45 degrees. He then looked away from the aircraft, and when he looked back, all that could be seen was a large plume of black smoke. Another witness, a boy about 10 years old, was about 150 m beyond the end of runway 28. He said that after the aircraft became airborne, it rocked from left to right, with the left bank angle gradually increasing. He said that the left wing then `snapped', referring to a rapid movement upwards, but did not separate from the aircraft, and the aircraft then descended rapidly to the ground. Both the boy and another witness about 700 m south of the departure end of the runway described engine noise consistent with normal operation, while two witnesses about 4.5 km north of the departure end of the runway reported that the engines sounded like they were `struggling'. The witness located 700 m south of the departure end of the runway heard two popping sounds immediately before a loud bang and then saw a large plume of black smoke.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others	Total
Fatal	1	4	-	5
Serious	-	-	-	-
Minor	-	-	-	-
None	-	-	-	-

1.3 Damage to aircraft

The aircraft was destroyed by impact forces and post-impact fire.

1.4 Other damage

Nil.

1.5 Personnel information

The pilot was 43 years old and held a second class airline transport (aeroplane) pilot license endorsed with PA-23 type aircraft, and a class 1 medical certificate. He had owned and flown the accident aircraft since August 1996. The pilot's logbook was not located. During his most recent medical examination conducted in February 2003, the pilot reported having accrued 3,700 hours flight experience, including 20 hours in the preceding 6 months. During July and September 2003, the pilot underwent 4 check flights in the accident aircraft totalling 4.3 hours with an experienced instructor. The check flights included normal and emergency operations, including practice in handling engine failures after take-off.

The family had been on a holiday in North Queensland, during which they had visited a number of other destinations. They had flown in to Mareeba on 28 September and stayed in Cairns. The pilot's activities and sleeping patterns during his stay in Cairns could not be determined. Prior to departure, the pilot spoke to several people by telephone and at the Mareeba aerodrome, none of whom noted anything unusual about his demeanour.

1.6 Aircraft information

1.6.1 Fuel

Prior to departure from Mareeba, the pilot refuelled the aircraft with 216 L of avgas. The pilot was observed refuelling all six aircraft fuel tanks prior to departure. Based on estimated flight times and fuel consumption rates from the time the aircraft was last known to have full fuel tanks, the pilot probably filled all six tanks at Mareeba to capacity, a total fuel quantity of approximately 708 L. No fuel was able to be recovered from the aircraft wreckage. Other aircraft operators who refuelled from the Mareeba aerodrome avgas bowser on the day of the accident did not report any fuel quality-related problems. Laboratory testing of avgas from the Mareeba Aerodrome bowser established that the sample met the specification for avgas.

1.6.2 Weight and balance

With full fuel tanks and using the pilot's weight from his most recent medical examination and standard passenger weights for the other four occupants (71 kg for the pilot's wife and 44 kg for each of the three children), the weight of the aircraft would have been 2,292 kg excluding baggage, 66 kg less than the VFR maximum takeoff weight of 2,358 kg. The extent of fire damage prevented any on-site assessment of the amount of baggage on board the aircraft. A witness who assisted the family with their baggage earlier in their trip said the family had two briefcases, two plastic bags, and two large sports bags. Witnesses at Mareeba aerodrome saw a blue cooler bag and some child-size backpacks near the aircraft prior to departure.

It was reported that the family normally flew with one child in the front and the pilot's wife and their other two children in the second row. However, it was not possible for the investigation to establish the seating positions of the occupants on the accident flight. Assuming the occupants were seated as reported, and little or no baggage was stored in the nose baggage compartment, the aircraft centre of gravity would have been within limits at the maximum take-off weight and zero fuel weight. The stabilator trim was within the range of normal take-off settings.

1.6.3 Maintenance

The pilot had owned and flown the accident aircraft for 8 years. During the two weeks prior to the accident he had completed about 12 hours flying over 8 flights.

A 100-hourly periodic inspection was completed on 6 August 2003 when the aircraft had accrued 4,396.6 hours total time in service. At the time of that inspection, the left engine had accrued 391.7 hours time since overhaul (TSO), the right engine 504.4 hours TSO. Both propellers had accrued 676.4 hours TSO. The aircraft logbooks indicated compliance with all applicable airworthiness directives. Maintenance action on the flight controls during the August periodic inspection included replacement of the pins and bolts used as rudder, aileron and flap hinges, the rear rudder trim cable and a rudder cable pulley bolt. The aircraft's total time in service at the time of the accident could not be established as the aircraft's maintenance release was not recovered.

1.6.4 Aircraft performance

The Piper Aztec *Pilot's Operating Manual* included a take-off distance chart. The chart indicated that with both engines operating, and a take-off weight of 2,358 kg, the aircraft would require a take-off distance[1] of about 585 m[2].

The Piper Aztec take-off distance chart did not include any provision to calculate the effect of a tail-wind component on take-off performance. UK CAA General Aviation Safety Sense leaflet 7B *Aeroplane Performance* advised that a tail-wind component of 10% of the lift-off speed would increase take-off distance by 20%. The lift-off speed for the Piper Aztec was 69 kts. The leaflet did not provide any data on the extent to which a runway down-slope would reduce take-off distance.

The actual tail-wind component when the aircraft took off could have been 13 kts, based on the witness information and the data from the automatic weather station. Under those conditions, the tail-wind component would have been 20% of the lift-off speed, and the expected take-off distance would increase to 819 m. The accident pilot may have used a rolling take-off, in which case the expected take-off distance would be further increased, although it was not possible to determine the extent of that increase.

The *Pilot's Operating Manual* indicated that with both engines operating, the aircraft should have been capable of a climb rate of about 1,280 ft/min[3] at the best rate of climb speed of 100 kts.

The investigation estimated[4] that the aircraft would have crossed the road 90 m beyond the end of the runway at approximately 285 ft AGL.

An aircraft's aerodynamic stall speed increases as bank angle increases. The Aztec *Pilot's Operating Manual* indicated that with the landing gear and flaps retracted and at maximum take-off weight, the aircraft would stall at 64 kts. With the aircraft at an angle of bank of 30 degrees, the stall speed would increase to 69 kts, and at an angle of bank of 60 degrees, the stall speed would be 90 kts. The manual did not provide any information on the stall speed at angles of bank greater than 60 degrees.

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[1] Take-off distance is the distance to accelerate from a standing start with all engines operating and to achieve the take-off safety speed at a height of 50 ft above the take-off surface.
[2] This figure was derived using temperature 27 degrees Celsius, pressure altitude 1,560 ft, a level runway, nil wind and full power set before brakes release.
[3] Using an aircraft weight of 2,358 kg and a density altitude of 3,200 ft.
[4] Assuming full power set before brakes release, a constant tailwind of 13 kts, constant acceleration between the commencement of the take-off roll and best rate of climb speed, and nil effect from the slight runway downslope.

1.6.5 Effect on flight of an open cabin door

Several pilots provided unsolicited opinions regarding the effect of an open cabin door on the flying characteristics of C, D and E model Aztec aircraft. The accident aircraft was an E model. One pilot experienced extreme control column vibration and general buffeting when the cabin door opened during cruise. In another occurrence, the pilot reported that the cabin door opened just after take-off, at which time there was significant left wing drop and he later described the aircraft as `unflyable'. Another pilot report said an open cabin door had a hazardous effect on aircraft controllability and performance.

A review of the ATSB aviation accident and incident database identified 26 reported occurrences since 1969 involving Piper Aztec cabin doors opening in flight, none of which resulted in an accident. On most occasions it was recorded that the pilot elected to return to the departure aerodrome or divert to a nearby aerodrome. One pilot reported airframe vibration, while another advised ATC that she was descending the aircraft due to an emergency, which she later advised was an open cabin door. A review of the US National Transportation Safety Board (NTSB) aviation database identified 16 accidents reported since 1970 involving Piper Aztec cabin doors opening in flight.[5] In most cases, the NTSB concluded that the open cabin door created a significant distraction that reduced the pilot's ability to maintain control of the aircraft.

1.7 Meteorological information

At the time of the accident, the weather at Mareeba was fine with a recorded temperature of 27 degrees Celsius. The Mareeba automatic weather station recorded that the average wind speed for the 10 minutes prior to the accident was 8 kts, the maximum gust strength was 13 kts, and that the average wind direction during that period was 027 degrees. Under those conditions, an aircraft taking off from runway 28 would have encountered up to approximately 4 kts of tail wind. The standard deviation[6] of the wind direction was 29 degrees.

1.8 Aids to navigation

Not a factor in this occurrence.

[5] The NTSB database has a focus on accidents as mandatory reporting of incidents is not required in the US (unlike Australia).

[6] The standard deviation of a data set indicates how close the individual numbers in the set are to the average.

1.9 Communications

Radio transmissions on the Mareeba common traffic advisory frequency (CTAF) were recorded. At 1137 Eastern Standard Time, the pilot broadcast a normal taxiing call on the Mareeba CTAF. There was no evidence that any other aircraft was operating in the Mareeba CTAF at the time.

1.10 Aerodrome information

Mareeba aerodrome was 1560 ft above mean sea level. Runway 28 was 1505 m long and on average sloped down 0.55%. There was a copse of 15 m high trees near the western end and just north of the runway strip.

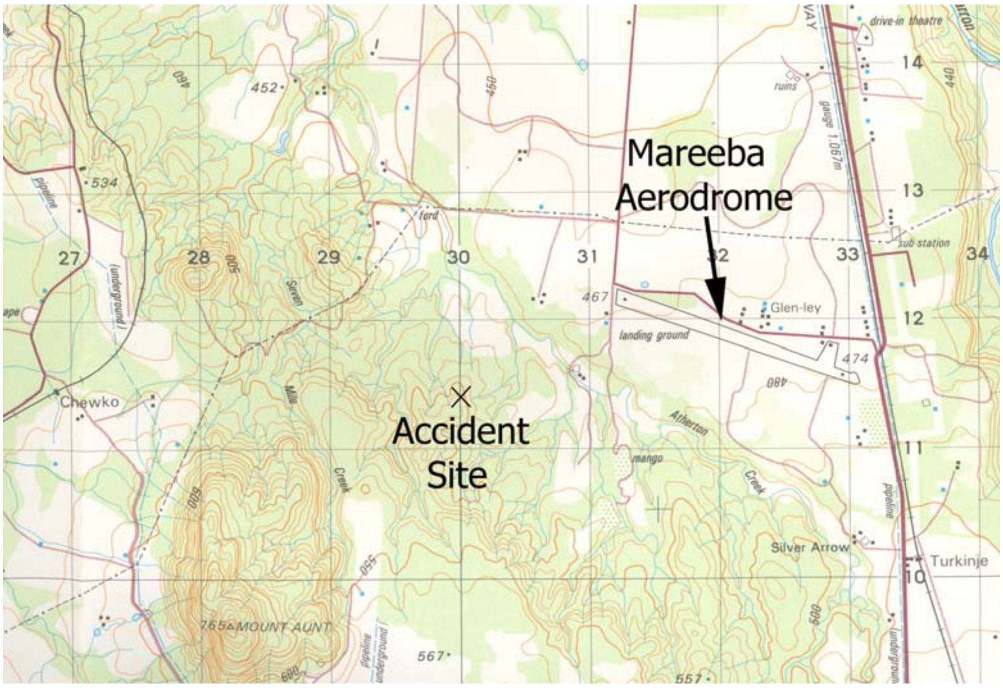
1.11 Flight recorders

The aircraft was not fitted with a flight data recorder or cockpit voice recorder, nor was it required to be by relevant aviation regulations.

1.12 Wreckage and impact information

The accident site was located on a lightly timbered ridge, 1.5 km west-southwest of the Mareeba aerodrome reference point, at an altitude of 1,640 ft above mean sea level and 80 ft above aerodrome elevation (refer figure 1).

Figure 1. Location of accident site relative to aerodrome



The aircraft collided with several trees before impacting the ground. At the time of impact, the aircraft was inverted and in a nose-low, nearly vertical attitude, rolling to the left and tracking approximately 090 degrees magnetic. The wreckage came to rest approximately 6 m from the initial ground impact.

An intense post-impact fire resulted in significant melting and destruction of much of the aircraft structure and components (refer figure 2). The fire damage prevented a conclusive determination of the functionality of the aircraft's systems prior to impact. All aircraft extremities were located at the accident site and the distribution of the wreckage indicated that the aircraft did not sustain a major structural failure prior to impact. The landing gear and flaps were retracted at impact, and the rudder and horizontal stabilator trim tabs were within the range of normal take-off positions. Propeller and impact evidence indicated that both engines were delivering substantial power at the time of impact. The wreckage examination did not identify any pre-existing defect that could have contributed to the development of the accident. A small piece of recovered windscreen did not exhibit any evidence of a birdstrike.

Figure 2. Aircraft destroyed by impact forces and post-impact fire

Although the engines were badly damaged by fire, a teardown inspection did not identify any evidence that either engine was incapable of delivering power prior to impact. A detailed examination of both propeller pitch change mechanisms indicated that both propellers were in the full fine pitch position at the time of impact.

The remains of the cabin door were located immediately adjacent to the right of the fuselage, on top of the remains of the right wing. Because of the extent of airframe destruction, the investigation could not establish from the door itself whether it had been closed or open at impact (refer figure 3).

Figure 3. Burnt cabin door

1.13 Medical and pathological information

1.13.1 Post mortem and medical history

Post mortem examination of the five occupants of the aircraft indicated that none survived the initial impact. Examination of the pilot identified significant narrowing of the coronary arteries. Examination of the heart tissue identified an area of cellular damage, possibly resulting from a recent (within days or weeks) disruption of oxygen supply to the heart, and also identified possible long-standing ischaemic[7] changes. A specialist aviation forensic pathologist who assessed the post-mortem reports on behalf of the ATSB concluded that it was `likely that the pilot was incapacitated during flight, given the extent of coronary artery disease present at autopsy'. There was no evidence that medication, alcohol, carbon monoxide or other toxic substances adversely affected the pilot at the time of the accident.

Examination of the pilot's kidneys identified changes that suggested mild hypertension. The pilot's blood pressure was recorded as within limits during all aviation medical examinations dating back to 1991. His systolic

[7] Defined by the Merriam-Webster Medical Dictionary as `localised tissue anemia due to obstruction of the inflow of arterial blood (as by the narrowing of arteries by spasm or disease)'.

blood pressure[8] was consistently well below the acceptable upper limit stipulated by the Civil Aviation Safety Authority (CASA), whereas his diastolic blood pressure[9] was only marginally below the upper limit during more recent medical examinations. The pilot's diastolic blood pressure during a pre-employment medical on 21 March 2002 was 100 mmHg. This was slightly above the CASA upper limit of 95 mmHg.

The results of the pilot's blood tests conducted in November 1995 and June 2001 indicated marginally elevated cholesterol levels, or mild hyperlipidaemia.

Hypertension and hyperlipidaemia are risk factors associated with the development of coronary heart disease. The specialist commented that the identifiable risk factors for the development of coronary heart disease were sufficiently mild to only be significant in retrospect and with the addition of autopsy findings. The nature of incapacitation as a result of an ischaemic cardiac event could have ranged from chest pain and shortness of breath, to loss of consciousness and cardiac arrest. A cardiac event may be precipitated by an event such as an acute stressor. Smoking is also a risk factor associated with the development of coronary heart disease, however there was no evidence that the pilot had ever smoked.

1.13.2 Medical certification aspects

A class 1 medical certificate was the highest category of medical certification available to pilots, and stipulated the most stringent requirements prior to issue, and was valid for 12 months. The accident pilot was issued a class 1 medical certificate on 27 February 2003. A valid medical certificate was required for the pilot to exercise the privileges of his pilot's license, which included acting as sole pilot in command of fare-paying passenger carrying operations.

CASA established and monitored pilot medical standards. Designated Aviation Medical Examiners (DAMEs) were appointed by CASA to conduct medical examinations and report the results to CASA.

CASA Aviation Medical personnel advised that CASA requires pilots renewing a class 1 medical certificate to undergo an electrocardiograph (ECG) on the first renewal after the 25th, 30th, 32nd, 34th, 36th, 38th and 40th birthdays, and annually thereafter. However, CASA only requires a DAME to submit a pilot's ECG report at 5 year intervals unless the DAME finds an abnormality .The most recent ECG report in CASA's records was conducted in 2001. CASA also required that class 1 certificate applicants undergo a cholesterol test during the first medical examination after the 25th birthday, and after every fifth birthday thereafter. Cholesterol tests of the accident pilot were conducted in November 1995, when he was 35, and June 2001, when he was 41 years of age.

[8] The systolic blood pressure is the peak arterial blood pressure during the cardiac cycle.
[9] The diastolic blood pressure is the lowest arterial blood pressure during the cardiac cycle.

When assessing applicants for a medical certificate, CASA used the *Coronary Heart Disease Risk Factor Prediction Chart* to determine the likelihood of a cardiac event. The risk factor chart assigned numeric values to age, gender, systolic blood pressure, high density cholesterol level, total cholesterol level, smoking status, diabetic status and ECG indications of heart enlargement. Combining the assigned values provided an indication of the risk of a cardiac event. If the result was 15 or greater, equivalent to a 10% risk of a cardiac event within 10 years, CASA required the applicant to undergo further medical assessment. Based on the results from his medical examination in February 2003, his cholesterol levels from 2001 (a cholesterol test was not required in 2003) and his most recent ECG (conducted in 2001), the accident pilot's cardiac event risk index value was 11. This risk index value was equivalent to a cardiac event risk of 6% within 10 years, or equivalent to the average for males aged between 40 and 44.

The *Coronary Heart Disease Risk Factor Prediction Chart* was developed by CASA, based on data from an ongoing longitudinal study of the population of Framingham, Massachusetts, USA, which commenced in 1948. The Framingham study has contributed to the identification of the major cardiovascular disease risk factors, and has produced approximately 1,200 articles in leading medical journals. Other researchers have produced risk factor indexes based on the Framingham data that include diastolic blood pressure. Use of one such index[10], and using a diastolic pressure of 100 mmHg, indicated that the accident pilot had a cardiac event risk of 10% within 10 years.

The use of systolic blood pressure in the calculation of the probability of a cardiac event may not reflect the latest information regarding age-related changes in the relative significance of systolic and diastolic blood pressure. One study[11] stated that "[diastolic blood pressure] is a more potent cardiovascular risk factor than [systolic blood pressure] until age 50; thereafter [systolic blood pressure] is more important".

1.14 Fire

The aircraft wreckage was consumed by an intense post-impact fire. There was no evidence of an in-flight fire.

[10] Wilson, P.W.F., D'Agostino, R.B., Levy, D., Belanger, A.M., Silbershatz, H., & Kannel, W.B. 1998. Prediction of coronary heart disease using risk factor categories. *Circulation.* **97.** pp1837-1847.

[11] Chobanian, A.V., Bakris, G.L., Black, H.R., Cushman, W.C., Green, L.A., Izzo Jr, J.L., Jones, D.W., Materson, B.J., Oparil, S., Wright Jr, J.T., Roccella, E.J. & the National High Blood Pressure Education Program Coordinating Committee. 2003. Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure. *Hypertension.* **42.** p1206.

1.15 Survival aspects

The accident was not survivable, due to impact forces and post-impact fire.

1.16 Tests and research

Nil.

1.17 Organisational and management information

Not a factor in this occurrence.

1.18 Additional information

1.18.1 Recorded information

Although secondary radar coverage was available down to ground level at Mareeba, there was no recorded radar data for the accident flight, indicating that the aircraft transponder was either not turned on, or was not serviceable.

1.19 New investigation techniques

Not a factor in this occurrence.

2 ANALYSIS

The identification of the factors that contributed to the development of the accident was hampered by significant destruction of the aircraft by post-impact fire, limited witness information and minimal recorded information. No pre-existing defect was identified that could have affected the airworthiness of the aircraft.

The witnesses who said the engines sounded like they were `struggling' were over 4 km away from the aircraft, and the distance and prevailing gusting wind could have adversely affected their ability to hear the aircraft clearly. The normal engine operating sounds reported by witnesses closer to the aircraft provided a more reliable indication of engine operation just after take-off. Assuming the wind conditions were the least favourable, the reported height of the aircraft as it passed over the road just beyond the end of the departure runway was consistent with the expected performance of the aircraft based on the existing conditions and the performance data in the aircraft documentation. With normal engine power available from both engines, the aircraft should have been capable of outclimbing any downdrafts associated with mechanical turbulence induced by the copse of trees near the end of the departure runway in the moderate strength wind conditions existing at the time of take-off.

The witness description of the left wing `snapping' was not supported by the physical evidence at the accident site. However, a rapid roll, which may occur if one wing stalls, could appear to an observer as if a wing had snapped. An aerodynamic stall would have become progressively more likely as the bank angle increased.

The apparently unstable aircraft flight behaviour reported by witnesses, the gradually increasing and uncorrected left bank, and the subsequent rapid descent and inverted, nose-low and near vertical impact attitude are consistent with pilot incapacitation. Additional supporting evidence is provided by the post-mortem, which found that the pilot had significant coronary artery disease. There are many possible abnormal or emergency events that could occur during the take-off phase of a flight, including the door popping open, which might have triggered a cardiac event. The available evidence was insufficient to exclude other incapacitating events such as a birdstrike penetrating the windscreen. The evidence from the ATSB and NTSB databases does not support the assertion that an Aztec is uncontrollable during flight with the cabin door open. The investigation was unable to determine if the cabin door was open during the accident flight.

The results of blood pressure readings during the pilot's routine pilot medicals indicated that his diastolic blood pressure was only marginally below the upper limit determined by CASA, whereas his systolic blood pressure was substantially less than the upper limit. The pilot's diastolic blood pressure reading taken on at least one other occasion was above the upper limit. The system used by CASA to identify the risk of a cardiac event in applicants for pilot medical certificates did not utilise diastolic blood pressure.

3 CONCLUSIONS

3.1 Findings

1. The pilot was appropriately licensed to conduct the flight, and held a valid medical certificate.

2. The aircraft was probably within weight and balance limitations.

3. Witnesses in the best positions to hear the aircraft after take-off reported engine sounds consistent with normal engine operation.

4. Shortly after it became airborne, the aircraft commenced a gradual bank to the left.

5. Control of the aircraft was lost at a height from which recovery was not possible.

6. The aircraft impacted the ground in an inverted, steeply nose-low attitude.

7. Although impact forces and intense post-impact fire destroyed much of the aircraft structure and components, examination of the wreckage did not identify any pre-existing defect.

8. The accident was not survivable.

9. Post-mortem examination of the pilot identified significant coronary heart disease.

10. The pilot’s available medical history indicated he was affected by mild hypertension and mild hyperlipidaemia.

11. There are many abnormal or emergency events that could occur during take off that could have triggered a cardiac event.

12. The pilot was not identified by CASA’s system of assessing applicants for medical certificates as having an unacceptable risk of a cardiac event.

3.2 Significant factors

Control of the aircraft was lost at a height from which recovery was not possible. The reason for the loss of control could not be conclusively established, however the circumstances of the accident and the available evidence were consistent with pilot incapacitation associated with coronary heart disease. Other possibilities, either individually or in conjunction with pilot incapacitation could not be excluded.

4 SAFETY ACTION

As a result of this occurrence, the Australian Transport Safety Bureau issues the following safety recommendation:

R20040091

The Australian Transport Safety Bureau recommends that the Civil Aviation Safety Authority review the medical certification standards to consider the potential increased significance of diastolic blood pressure to the risk of a cardiac event in applicants for an aviation medical certificate.