Australian Government
Australian Transport Safety Bureau

ATSB TRANSPORT SAFETY INVESTIGATION REPORT
Aviation Occurrence Investigation – 200601640
Final

Loss of control
4 km ENE Archerfield Airport, Qld
31 March 2006
VH-BST
Amateur built Lancair 320

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Abstract

At 0728 Eastern Standard Time on 31 March 2006, an amateur-built Lancair 320 aircraft, registered VH-BST, departed Townsville, Qld, on a private flight to Archerfield, Qld. At 1058, shortly after flying past the destination airport, the aircraft departed controlled flight and impacted the ground. The aircraft was destroyed and the pilot sustained fatal injuries.

The loss of control was consistent with an accelerated aerodynamic stall, at a height from which it was not possible to recover, followed by the aircraft entering a spin to the left prior to impact. The loss of control occurred when the pilot was operating in adverse weather conditions of low cloud, was tracking towards an area of reduced visibility in rain and towards terrain that was higher than the aircraft.

The pilot's decision to continue the flight into instrument meteorological conditions, even though neither he nor the aircraft were certified to operate is those conditions, increased safety risk. The pilot's ability to fly the aircraft and manage the flight was limited by his relative lack of experience on high performance aircraft, and deficiencies in the training that he had received on the Lancair.

Some aerodynamic and flight control characteristics of the Lancair 320 aircraft increased the risk of an accident. However, those characteristics were largely a consequence of the role for which the aircraft had been designed. In order to operate Lancairs and other high-performance amateur-built experimental aircraft safely, pilots need to be aware of, and maintain the aircraft within, the safe operational envelope.

In response to this and other accidents involving amateur-built experimental aircraft, the ATSB is conducting further research on safety aspects of these types of aircraft.

THE AUSTRALIAN TRANSPORT SAFETY BUREAU

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

The ATSB is responsible for investigating accidents and other transport safety matters involving civil aviation, marine and rail operations in Australia that fall within Commonwealth jurisdiction, as well as participating in overseas investigations involving Australian registered aircraft and ships. A primary concern is the safety of commercial transport, with particular regard to fare-paying passenger operations.

The ATSB performs its functions in accordance with the provisions of the *Transport Safety Investigation Act 2003* and Regulations and, where applicable, relevant international agreements.

Purpose of safety investigations

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

It is not the object of an investigation to determine blame or liability. However, an investigation report must include factual material of sufficient weight to support the analysis and findings. At all times the ATSB endeavours to balance the use of material that could imply adverse comment with the need to properly explain what happened, and why, in a fair and unbiased manner.

Developing safety action

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

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

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

FACTUAL INFORMATION

History of the flight

At 0728 Eastern Standard Time[1] on 31 March 2006, an amateur-built Lancair 320[2] aircraft, registered VH-BST (BST), departed Townsville, Qld, on a private flight to Archerfield Airport, Qld. The pilot, who owned the aircraft and was the sole occupant, had earlier submitted a visual flight rules (VFR) flight plan for the flight. Weather conditions in the Archerfield area included low cloud and reduced visibility in rain, and the pilot did not locate the airport. At 1058, shortly after flying past the destination airport, the aircraft departed controlled flight and impacted the ground 4 km east-north-east of Archerfield (Figure 1). The aircraft was destroyed and the pilot sustained fatal injuries.

Figure 1: Accident location

The pilot had not previously flown to Archerfield[3]. Prior to the flight, he reviewed the printed and audio-visual information describing the procedures for operating in

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

2 The aircraft was built from a kit supplied by Neico Aviation Incorporated.

3 Archerfield was a busy, general aviation aerodrome south-west of Brisbane Airport, and operations in the area required compliance with specific, detailed procedures.

the Archerfield area, and reviewed the requirements with the manager[4] of the local flying school.

On the morning of the flight, the pilot left home, after having breakfast, at about 0530. He had originally planned to depart Townsville at sunrise[5]; however, unsuitable weather conditions resulted in a delayed departure. When the manager arrived at the airport, he found the pilot was about to depart and anxious to get going. The manager spoke to the pilot while he was sitting in his aircraft. The manager reviewed the pilot's fuel planning figures for the flight to Archerfield in order to satisfy himself that the aircraft was carrying sufficient fuel for the flight. He also spoke to the pilot about the procedures for operating at Archerfield, and asked him about the weather. The pilot indicated that he had looked at the forecast, and would divert to an alternate airport if he was unable to land at Archerfield. The manager saw that the pilot had documents attached to the flight plan, which appeared to be weather and operational information. He did not look at the forecast, nor did he discuss the weather and weather-related operational decision-making in depth with the pilot, nor was this required. The manager noted that the pilot had a portable Global Positioning System (GPS) unit positioned on the glareshield (on the top of the instrument panel). A break in the weather then allowed the pilot to depart Townsville.

The following chronology of events was derived from radar data and recordings of the air traffic control communications with the pilot:

10:48:30	The pilot contacted the Archerfield Aerodrome Controller and reported that he was 19 miles (35 km) from the airport and inbound. He said that he was new to the area and would appreciate any help. The controller advised the pilot to contact the Brisbane Radar Controller if he required radar assistance, otherwise he should report at the TV towers (a VFR reporting point 13 km north-west of Archerfield). The aircraft was maintaining about 3,700 ft AMSL (above mean sea level).
10:52:13	The pilot reported that he was at the TV towers. The controller asked the pilot to confirm that he was able to fly visually to Archerfield, to which the pilot responded 'at this stage it looks like I can'. The controller instructed the pilot to report crossing the Brisbane River at the Centenary Bridge. The aircraft was maintaining about 2,200 ft AMSL.
10:55:15	The controller advised the Brisbane Radar Controller via intercom that the weather appeared to be clearing up, and that in about 15 to 20 minutes, it would be a lot better.
10:55:20	The pilot reported that he was crossing the Brisbane River at the Centenary Bridge, and that he was 7 NM (13 km) west of the airport. The controller responded that, based on radar information, it appeared the aircraft was at the Indooroopilly Bridge, about 4 NM (7.5 km) north-west of the airport. The controller instructed

4 The manager held a flight instructor rating and was the chief pilot of an aircraft charter company associated with the flying school.

5 0619 according to Geoscience Australia sunrise/sunset calculator.

the pilot to join the circuit on a base leg for runway 10 Left, and to report on base.

10:56:49	The pilot requested the height of the cloud base at the airport. The controller advised that the cloud base was probably 800 to 1,000 ft above ground level (AGL) (850 to 1,050 ft AMSL). The aircraft was at an altitude of 1,600 ft AMSL.
10:57:14	The controller asked the pilot if he had the airport in sight. The pilot replied that he had not identified the airport. Radar data showed that the aircraft was 2 km north of the airport at 1,700 ft AMSL, and tracking south-south-east.
10:58:11	The controller again asked the pilot if he had the airport in sight. The pilot said that he did not, and said 'I feel I've overflown it'. The controller advised that radar information indicated that the aircraft was north of the airport, and he suggested that the pilot continue to turn left and come back towards the field. The pilot then acknowledged that transmission. No further radio transmissions were received from the pilot.
10:58:29	The controller advised the pilot that the tower radar display showed the aircraft at 400 ft, which was very low.
10:58:30	The last valid radar information showed the aircraft about 4 km north-east of the airport at 400 ft AMSL and tracking east-north-east with a groundspeed of around 105 kts.

A witness located about 4 km north-east of Archerfield Airport saw the aircraft fly low over her house in straight and level flight, tracking east-north-east towards the Queen Elizabeth II Stadium (612 ft AMSL) and Mt Gravatt (712 ft AMSL) (see Figure 1). She reported that as she watched the aircraft fly away from her, she heard the engine noise stop. The aircraft's left wing then dropped and it appeared to enter a spin to the left before it descended out of sight behind trees. Another witness, who was working in the grounds of the Queensland Health Scientific Services facility and close to the accident site, reported seeing the aircraft flying straight and level, and low, directly towards him. He said the engine noise did not miss or change pitch. He then saw the aircraft bank right, then flip onto its left side and descend straight down, colliding with a tree and then a creek running parallel to Kessels Road, Coopers Plains.

The aircraft was destroyed and the impact was not survivable.

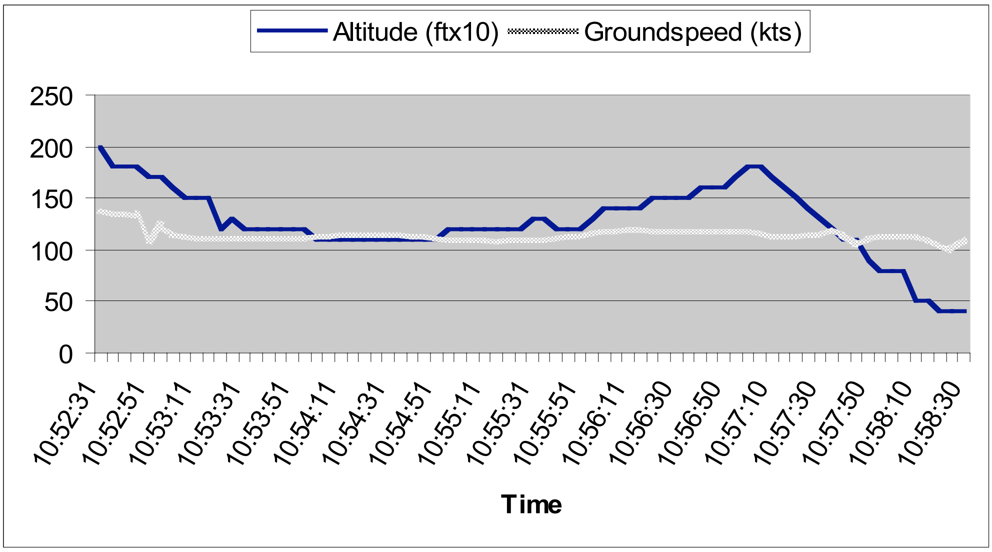
Recorded information

Radar position and altitude information from the aircraft's transponder was received and recorded by the Airservices Australia air traffic control system. This information is overlaid on the Brisbane Visual Terminal Chart in Figure 2.

Figure 2: Radar track

Examination of the radar information indicated that as the aircraft approached Archerfield, it descended at high rates (Figure 3), up to approximately 1,200 ft per minute for short periods of time.

Figure 3: Aircraft altitude and groundspeed



Wreckage examination

The accident site was 4 km east-north-east of Archerfield Airport, near the northern boundary of the grounds of the Queensland Health Scientific Services facility. The aircraft initially collided with trees before coming to rest in a creek. Most of the aircraft components were located in or on the banks of the creek (Figure 4), with a few components recovered from Kessels Road.

Figure 4: Accident site

An examination of the accident site and aircraft wreckage indicated that:

- the aircraft was in a steep nose-low, near vertical pitch attitude at the initial impact point
- the aircraft was rotating rapidly to the left around the vertical axis at the time of impact
- damage to the propeller was consistent with the engine delivering power at the time of impact
- the frangible plastic drive shaft of the engine-driven vacuum pump was intact
- there was no evidence of any pre-impact structural or flight control defects
- the wing flaps were positioned at the cruise flight setting of -7 degrees[6]
- the aircraft altimeter subscale was set to 1015.

The investigation estimated that the aircraft had around 50 litres of fuel on board at the time of the accident, sufficient for about 85 minutes of additional engine operation at the cruise fuel consumption rate with no reserves. The investigation determined that the aircraft's weight and centre of gravity were most likely within limits for the duration of the flight.

Laboratory examination of the electrical turn and bank indicator identified rotational scoring, which indicated that electrical power was available to the instrument at, or immediately prior to impact. Rotational scoring to the vacuum-driven gyroscope in the artificial horizon indicated that vacuum was available to the instrument at, or immediately prior to impact.

6 The Lancair Pilot's Operating Handbook described a flap setting of -7 degrees as 'faired'. The aircraft flight manual specified the take-off flap setting as between 0 and 10 degrees, and the landing flap setting as 40 degrees.

It was not possible to obtain any recorded information from any of the three GPS units on board the aircraft. One of the portable GPS units was recovered from Kessels Rd, along with fragments of window perspex and propeller blades.

Weather information

Forecast weather

The Australian Bureau of Meteorology (BoM) issued an aviation weather area forecast for the Brisbane area at 0128 on 31 March 2006, which was valid from 0300 to 1800. The forecast indicated that there would be rain areas developing by 0900, isolated thunderstorms after 1000, and patches of low cloud. The forecast indicated that cloud in the Brisbane area would include isolated cumulonimbus cloud between 4,000 and 35,000 ft from 1000, broken[7] stratus cloud between 1,000 and 3,500 ft in rain, and scattered cumulus and stratocumulus cloud between 2,500 and 9,000 ft near the coast. Expected weather included thunderstorms, showers and rain, and visibility was expected to be 2,000 m in thunderstorms and 4,000 m in rain and showers.

The BoM issued a Terminal Area Forecast (TAF) for Archerfield at 0420, which was valid from 0600 till 1800. The forecast included light rain, few cloud at 1,200 ft, scattered cloud at 3,000 ft, and broken cloud at 10,000 ft. Between 0800 and 1800, there was expected to be intermittent showers of rain with visibility reducing to 4,000 m and broken cloud at 1,000 ft.

A copy of the area forecast issued at 0128 on 31 March 2006 and the Archerfield TAF issued at 0420 was recovered from the aircraft wreckage.

An amended Archerfield TAF, issued at 0822, included a 30 percent probability of thunderstorms between 1000 and 1500.

Observed weather

Weather radar information provided by the BoM showed that a narrow band of rain and showers moved over Archerfield from the west at about 1040, and had cleared to the east by 1100. At the time of the accident, the weather radar showed areas of light rain to the east of the airport (Figures 5 and 6).

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7 Broken refers to 5 to 7 eighths (oktas) of the sky obscured by cloud, scattered refers to 3 to 4 oktas and few refers to 1 to 2 oktas.

Figure 5: Weather radar image at 1050

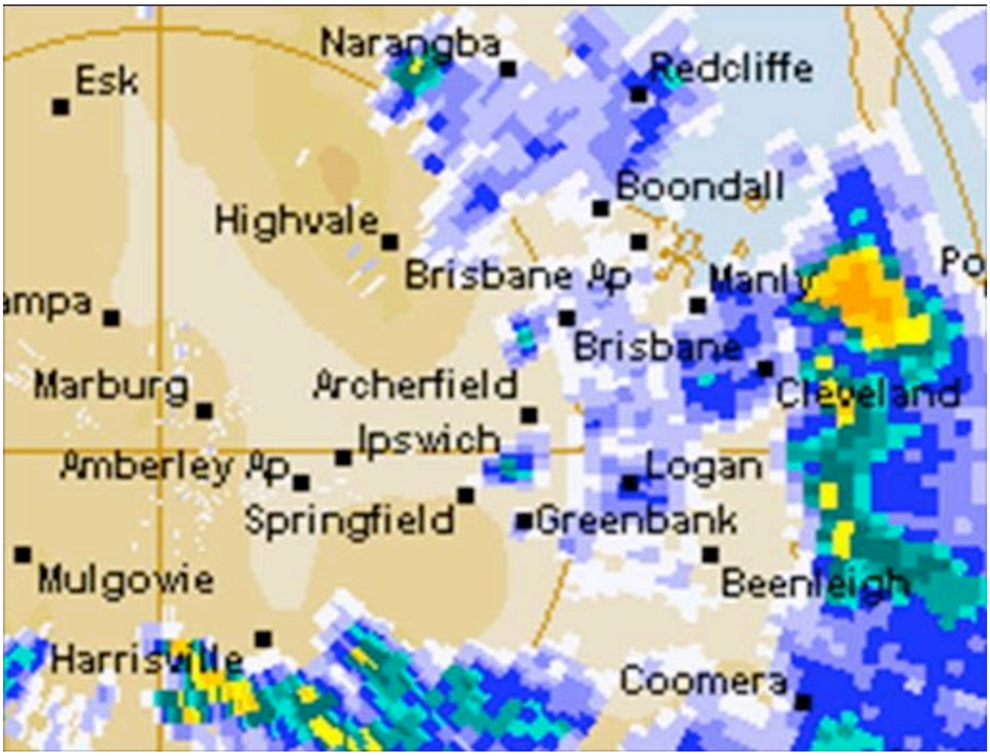

Figure 6: Weather radar image at 1100

Prior to 1056, Archerfield Automatic Terminal Information Service (ATIS) Echo broadcast that the wind was 160 degrees M at 10 kts, visibility was 4,000 m in rain, there was scattered cloud at 1,000 ft, and that the QNH was 1015 hPa. From 1056, Archerfield ATIS Foxtrot broadcast that the wind was 280 degrees M at 5 kts and there was broken cloud at 1,000 ft with lower patches.

The Archerfield Airport Weather Information Service (AWIS) recorded that at 1100 there had been 0.2 mm of rain in the previous 10 minutes, the mean wind for the previous 10 minutes was a westerly at 3 kts, and that the QNH was 1013 hPa.

The pilot[8] of a VFR flight who flew into Archerfield from the south-east about 15 minutes before the accident described the weather as marginal for VFR operations. He reported there was 2 to 3 oktas of cloud with a base of 800 ft and tops of 1,200 ft, and at least 6 oktas of cloud with a base of 1,600 ft. Another pilot, who was operating an IFR flight to the west of Archerfield about 5 minutes after the accident, reported 8 oktas of cloud with a base of 1,800 ft, and 4 to 5 oktas of cloud, with drizzle, with a base of 800 ft and tops of 1,000 ft.

A witness located close to the accident site reported that a heavy rain shower had just stopped, and that there was an unbroken cover of low cloud. There was cloud on the hills north of the accident site. Another witness reported that it was raining very lightly at the time of the accident.

Weather planning requirements

Pilots planning flights away from the vicinity of an airport were required to assess the current weather reports and forecasts for the route to be flown (Aeronautical Information Publication ENR 1.10). Forecast weather conditions inferior to specified criteria required a pilot to plan for an alternate destination airport, so that if weather conditions at the destination precluded a landing, the aircraft would have sufficient fuel and would be suitably equipped to divert to, and land at, the nominated alternate airport.

The pilot of a VFR flight was required to plan a suitable alternate airport when the weather conditions at the destination at the estimated time of arrival (or within 30 minutes after the arrival) included:

- more than 4 oktas of cloud below 1,500 ft AGL
- visibility less than 8 km (or visibility forecast with an associated percentage probability of reducing below 8 km), or
- wind or wind gusts greater than the crosswind or downwind limits applicable to the aircraft.

The expected cloud height and visibility specified on the Archerfield Terminal Area Forecast for the pilot's estimated time of arrival were better than the alternate minima. That TAF also indicated that periods of less than 30 minutes duration were expected when the cloud amount and height, and the visibility would be worse than the alternate minima, and therefore the pilot was required to either plan for an alternate airport, or carry 30 minutes of holding fuel.

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8 The pilot had completed instrument rating flying training and was preparing to undertake the instrument rating flight test.

The Visual Flight Rules

The Aeronautical Information Publication (AIP) ENR 1.2 paragraph 1.1.1 required that a visual flight rules (VFR) flight be conducted:

– in visual meteorological conditions (VMC), and

– if below 2,000 ft AGL, the pilot navigate by visual reference to the ground or water.

AIP ENR 1.2 paragraph 2.5 specified that within the Archerfield control zone, an aircraft was in VMC if:

– it was clear of cloud, and

– the pilot could maintain a flight visibility of at least 5,000 m.

AIP ENR 1.2 paragraph 2.6 specified that in Class G airspace at or below 3,000 ft AMSL or 1,000 ft AGL (whichever was the higher), an aircraft was in VMC if:

– it was clear of cloud

– the pilot was in sight of the ground or water, and

– the pilot could maintain a flight visibility of at least 5,000 m.

Instrument Flight Rules

Aircraft operating in conditions inferior to visual meteorological conditions were required to be operated under the instrument flight rules. These rules significantly reduced the risk of operating in bad weather conditions through, among other things, requiring:

– increased pilot skill in maintaining aircraft control without a visible horizon through additional training and recency requirements

– increased pilot skill in navigating without visual reference to surface features through additional training and recency requirements relating to the use of aircraft navigation equipment

– aircraft fitted with aircraft navigation equipment certified for use in instrument meteorological conditions (IMC)

– aircraft fitted with instrumentation with a high degree of operational reliability through technical standards

– pilots to carry and use charts detailing procedures that allowed an aircraft to be descended safely when the pilot did not have visual reference to the ground.

To conduct instrument flights safely required a pilot to be trained and current in all required aspects of instrument flight, which meant that he or she should hold a current instrument rating, and that the aircraft should be certified for operations in IMC.

Pilot information

Training and experience

The pilot passed his private pilot (aeroplane) licence flight test on 22 March 2005. At that time, his total flying experience was reported as 188.3 hrs. Logbook records and the records of the accident flight indicate that his total flying experience at the time of the accident was 302.1 hrs. He had accrued 29.5 hrs in Lancair aircraft (all in BST), of which 21.7 hrs were as pilot in command. He did not hold an instrument rating.

The pilot purchased the accident aircraft during late 2005/early 2006. At that time, he had only flown Cessna 172 and 172RG aircraft. The previous owner of BST, who had built the aircraft, arranged for an instructor with experience in Lancair aircraft to conduct a series of training flights with the pilot. These training flights were conducted in BST at Bankstown Airport, NSW, during early January 2006 and totalled 7.8 hrs flight time. Bankstown and Archerfield Airports are both General Aviation Aerodrome Procedures (GAAP) airports and use similar procedures to manage operations. The investigation did not locate any training records of the flights conducted in the Lancair at Bankstown. In his logbook, the pilot described all the Lancair training flights as circuit training. The instructor reportedly[9] told the pilot that he should do a further 20 hrs of local flying in BST with a safety pilot before flying the Lancair solo, although there was no regulatory requirement for him to do so. The investigation did not identify any evidence that the pilot complied with this recommendation.

The investigation spoke to another pilot who had been trained to fly his amateur-built Lancair 360 by the same instructor who had trained the accident pilot. The other pilot had about 210 hrs total flight experience at the time he purchased his Lancair, and his aircraft insurance company required him to complete 30 hrs with an instructor. At the end of the 30 hrs, this pilot did not feel entirely comfortable in the aircraft, and arranged for further training. The instructor's training program included numerous normal circuits, in addition to cross-wind, flapless, and glide approaches. The training program also included cross-country navigation exercises and upper air work, including steep turns. They did not conduct any aerodynamic stall exercises in the aircraft, nor did the instructor demonstrate an incipient stall – the instructor said that if they stalled the aircraft, they would not be able to recover control. At no time during the training did the airspeed reduce below about 80 kts, the final approach speed.

The private pilot (aeroplane) licence flight test form required that a candidate for a private licence demonstrate the following elements:

– enter and recover from a stall in the approach configuration

– enter and recover from a stall with wing drop[10]

9 The instructor was fatally injured in another aircraft accident five days after the accident involving BST, and before he could be interviewed by ATSB investigators. See ATSB report BO/200601688.

10 Stall training for the issuing of a private licence was generally conducted in aircraft with relatively benign stall characteristics, including minimal height loss.

– conduct a precautionary search & landing

– navigate at low level and in reduced visibility.

The Civil Aviation Safety Authority (CASA) *Day VFR Syllabus –Aeroplanes*[11] private pilot license elements 'navigate at low level and in reduced visibility' and 'conduct precautionary search and landing' required the pilot to set up the aircraft in the bad visibility configuration if weather conditions and visibility were unfavourable, and maintain an altitude of about 500 ft above ground level, or 100 ft below cloud. Although not defined in the syllabus, 'bad visibility configuration' was generally taken to mean reducing the radius of an aircraft's turns by reducing its speed. This may be achieved by various means, depending on the aircraft type, including extending partial flap. Extending flap also reduced an aircraft's aerodynamic stall speed.

The accident pilot completed all his private licence training and flight test in Cessna 172 and 172RG aircraft. His training records referred to precautionary search and landing exercises, and navigation at low level, but there was no specific reference to operating in reduced visibility, or establishing the aircraft in a bad visibility configuration.

The pilot commenced flying training in June 1996. For various reasons, the training was sporadic, with long periods of little or no flying. Instructor's comments in his flying training records suggested that although he was able to prepare and plan well, he had difficulty thinking ahead of the aircraft's current position and that he relied too much on the GPS.

Transition training requirements

The pilot of a single engine (piston) aeroplane below 5,700 kg maximum take-off weight required a class endorsement in addition to any applicable special design feature endorsements in order to act as pilot in command. The accident pilot held the appropriate class endorsement and special feature endorsements to act as pilot in command of the Lancair, having obtained these endorsements following training in Cessna 172 and 172RG aircraft.

In addition to the class and special feature endorsement requirements, a pilot must comply with the requirements of Civil Aviation Order (CAO) 40.1.0 section 4.4, which stated:

> The holder of a class endorsement must not fly as pilot in command or co-pilot of any aeroplane unless he or she:
>
> (a) is familiar with the systems, the normal and emergency flight manoeuvres and aircraft performance, the flight planning procedures, the weight and balance requirements and the practical application of take-off and landing charts of the aeroplane to be flown; and
>
> (b) has sufficient recent experience or training in the aeroplane type, or in a comparable type, to safely complete the proposed flight; and

11 Issue 3.2 – Effective 1 May 2007.

(c) if an aeroplane in that class has a special design feature, holds a special design feature endorsement referred to in paragraph 5.1 for that design feature.

At the time that the pilot completed his training, the CASA had not published any guidance specifically addressing transition training onto aircraft with the flight characteristics of the Lancair, or formal guidance as to how to comply with the CAO requirements.

In 1997, following a series of investigations of accidents involving amateur-built experimental aircraft, the US National Transportation Safety Board (NTSB) issued several related safety recommendations[12]. The NTSB stated that 'some accidents may be related to inadequate flight training by pilots who … transition into amateur-built aircraft, which have flight characteristics that are unfamiliar to them'.

The safety recommendation letter also included the following comments:

> The [NTSB] recognizes that the vast majority of pilots learn to fly in type-certificated aircraft, which have been tested and demonstrated to have stability, controllability, and performance characteristics that fall within a defined envelope. Further, after their training, most pilots continue to operate type-certificated airplanes, which comprise most of the general aviation fleet. Consequently, it may be difficult for them to transition to many amateur-built aircraft, which may have flight characteristics that fall outside the familiar envelope of type-certificated aircraft, without the benefit of transition training.
>
> …
>
> The [NTSB] concludes that type-specific flight training is critical for pilots transitioning into amateur-built experimental aircraft. …new owners who acquire amateur-built experimental aircraft in the secondary marketplace should have the opportunity to receive transition training, unless their prior flight experience makes it unnecessary.

Following successive fatal accidents involving amateur-built experimental Lancair aircraft in Australia (this accident was one of those events), CASA commissioned a panel to review Lancair operations. The panel's report was completed in June 2006, and included the following recommendation to CASA:

> That guidance material for transition and recurrent training be developed for flight crew of high performance experimental aircraft.

As of the publication of this report, no such guidance material had been published. Further information from the CASA Lancair Review Panel report is contained in the Aircraft Information section of this report.

72 hour history

On the night before the flight, the pilot was reported to have gone to bed at 2100. That day he had been at his home researching and planning the flight. During the previous days he had been involved with business activities. It was reported that there was nothing remarkable in any of his activities in the days leading up to the flight.

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12 National Transportation Safety Board. 1997. *Safety Recommendation Letter A-97-53 through -55.*

Medical information

At the time of the accident, the pilot was 56 years old and held a Class 2 aviation medical certificate valid till 28 January 2007. In 1994, he was diagnosed with depression and was prescribed the anti-depressant medication fluoxetine. He was taking this medication at the time of the accident. The pilot was first issued an aviation medical certificate in 1996, at which time CASA were advised that he was taking fluoxetine for depression. CASA obtained a report from the doctor who was treating the depression and obtained further reports on the status of the depression on each occasion the pilot's aviation medical certificate was renewed.

A post-mortem examination concluded that the pilot died instantly of multiple injuries that occurred as a consequence of the accident. The pathologist identified coronary atherosclerosis and scarring of the heart muscle, however he concluded that the pilot was alive at the time of impact. A toxicological examination identified therapeutic levels of fluoxetine, and no other drugs were detected.

A CASA report on antidepressant use in aviation[13] was published in 2006. Relevant points from this report included:

- Aeromedical certification of pilots taking anti-depressant medication was not widely practiced in the international aviation industry.
- Australia has been certifying pilots taking anti-depressant medication for over 15 years.
- CASA did not identify any Australian accident in which anti-depressant medication was a contributing factor.
- Fluoxetine belonged to the class of anti-depressant medications known as Selective Serotonin Re-uptake Inhibitors (SSRI). This class of anti-depressants has been shown to produce fewer negative side-effects in comparison with other classes of anti-depressant medication. These side-effects generally decreased with continued treatment.

The entry for fluoxetine in the MIMS Annual[14] noted that:

> because fluoxetine hydrochloride may impair judgement, thinking or motor skills, patients should be advised to avoid driving a car or operating hazardous machinery until they are reasonably certain that their performance is not affected.

The CASA report noted that research indicated adverse reactions to SSRIs were generally noted early in the treatment cycle, and that side-effects diminished with time as patients became physiologically accustomed to the drug.

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13 Ross, J., Crisp, D., Lambeth, L., Griffiths, K., Dear, K. & Emonson, D. 2005. *Antidepressant Usage and Civilian Aviation Activity in Australia 1993-2004 – An assessment of policy for the management of aircrew and air traffic controllers taking antidepressant medication.* Civil Aviation Safety Authority. Canberra, Australia.

14 *MIMS Annual*. 2006. CMPMedica. St Leonards, Sydney.

Aircraft information

Airworthiness certification

The Lancair 320 aircraft was a conventionally-configured, low-wing, two-seat aircraft constructed primarily of composite material. It was a relatively high performance aircraft that could cruise at speeds in excess of 180 kts using a single relatively low-powered type-certificated Lycoming IO-320 engine. The Lancair 320 was not type-certificated, which meant that it was not required to comply with any recognised airworthiness certification standards, including stability and control characteristics, and stall warning requirements.

The accident aircraft, serial number N239, was first entered on the Australian aircraft register in 1994. In 2003, following repairs required after an off-airport forced landing, the aircraft was issued with an experimental certificate.

At the time of the accident, the aircraft was operating with a valid maintenance release, which authorised flight by day under the visual flight rules only. No defects had been recorded on the maintenance release. At the time of the accident, the aircraft had accrued 583.7 hrs total time in service. A review of the aircraft's maintenance logbooks did not identify any issues that were likely to have contributed to the development of the accident.

The aircraft's special certificate of airworthiness was subject to a number of conditions, which were detailed in an annex to the certificate. These conditions included:

> Flight over any persons or dwelling shall be avoided to the greatest extent practicable. Except for take-off and landing, flight over any persons or dwelling shall be at such a combination of height or speed as to permit the pilot to glide clear of all persons and dwellings, in the event of an engine failure or other flight critical emergency.
>
> The operator of this aircraft should notify the control tower of the experimental nature of this aircraft when operating into or out of airport with operating control towers.
>
> This aircraft does not meet the requirements of the applicable, comprehensive, and detailed airworthiness code as provided by Annex 8 to the Convention on International Civil Aviation.

Aircraft equipment

The aircraft was fitted with gyroscopic flight instruments and an angle of attack indicator. It was fitted with a single Very High Frequency radio transceiver and a fixed, VFR-only Global Positioning System (GPS) unit. The pilot was also carrying two additional portable GPS units, neither of which met the technical standards for navigation in IMC. The aircraft was not fitted with any instruments capable of receiving signals from ground-based navigation aids.

The fixed GPS had an alpha-numeric display – it was not capable of displaying a 'moving-map'. With a destination and/or flight plan entered and correctly activated, the unit would display tracking (using a course-deviation indicator), distance, and other navigation information.

The portable GPS unit the manager observed positioned on the glareshield prior to the aircraft's departure from Townsville had a 'moving-map' display and a terrain and obstacle alerting feature. The pilot was reported to have a high degree of confidence in using this unit for navigation. The unit required a sequence of five discrete button pushes and dial rotations to display a track line from the aircraft's present position to the destination airport. If the aircraft approached terrain or obstacles, the unit alerted the pilot by displaying the terrain page on the active screen. The user could modify various parameters that specified the degree of proximity to terrain and obstacles at which the GPS would annunciate an alert. The terrain alerts could be disabled.

There was no artificial pneumatic stall warning device installed on the aircraft. The flight manual stated that 'slight aerodynamic buffet occurs 5 knots above the stall in all configurations'.

The angle of attack indicator had been installed in the aircraft shortly before it was sold to the accident pilot, but at that time it had not been calibrated[15]. The indicator provided constant visual indications of the aircraft's angle of attack, and visual and aural indications when the aircraft was approaching an angle of attack at which an aerodynamic stall would occur. At the time of the training flights at Bankstown, the instructor telephoned the builder and asked whether the uncalibrated indicator could be turned off as the aural warnings were activating during landing and were distracting. The builder suggested that the unit be disconnected. There was no evidence that the angle of attack indicator had been reconnected and calibrated following the training flights.

Aircraft stall characteristics

According to the aircraft flight manual, the aircraft stall speed at the maximum take-off weight with the flaps in the cruise (-7º) position was 67 kts indicated airspeed. The stall speeds with the flaps in the take-off (0º) and fully extended (40º) positions were 62 and 58 kts respectively.

Aerodynamic stalls can occur at higher indicated airspeeds – such stalls are referred to as accelerated stalls. These may occur during steep turns, pull-ups or abrupt and/or excessive applications of the flight controls. For example, at a 60-degree angle of bank in a level turn, the aircraft would have stalled at an airspeed about 41% higher than the unaccelerated stalling airspeed. Because they occur at higher than normal airspeeds, the onset of accelerated stalls may be more difficult to identify. Accelerated stalls tend to occur more rapidly, and the consequences (such as attitude change, wing drop and height loss) are more severe, than unaccelerated stalls.

The Lancair Pilot's Operating Handbook, issued by the kit manufacturer, contained the following warning regarding aerobatics:

> … [the] Lancair is a very "slick" aircraft thus speeds increase very rapidly during descents, stalls or incipient spins and you will consume great amounts of altitude during recovery.

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15 The process required to calibrate the indicator included a test flight. It did not require the involvement of a licensed aircraft maintenance engineer.

The builder conducted numerous stalls in BST. He commented that the natural stall warning was minimal, other than a nose-high attitude. Gentle stalls resulted in mild oscillations in pitch, however more abrupt stalls resulted in significant nose and wing drop. Stalls with significant nose drop resulted in the aircraft descending about 1,500 ft before the pilot was able to recover control.

Aircraft stability and flight control characteristics

Certification standards specify the minimum stability and control characteristics necessary for different categories of aircraft. By certifying an aircraft, national aviation authorities are in effect, stating that the aircraft meets the minimum standards, and is therefore, aerodynamically safe to fly. The Lancair 320 was not a certified aircraft, and there was, therefore, no assurance by any aviation authority that the aircraft met minimum stability or flight control standards.

The builder said that BST had a tendency to roll away from a wings-level attitude if the pilot was concentrating on another task (such as map-reading). He also said that aircraft's control stick forces were light in comparison with comparable certified fixed-wing aircraft.

CASA review of Lancair operations

The CASA Lancair Review Panel report included the results of a survey of Lancair pilots and owners. Issues identified by the survey respondents included:

- it was essential to manage speed, and this management was different to lower performance aircraft
- good aircraft handling and careful power management were required at low speeds in order to avoid high sink rates and stalls
- flight controls are sensitive, with low stick forces
- transition training is essential
- the aircraft was pleasant and safe to fly if flown appropriately
- there was minimal pitch change across the speed range
- the natural stall warning was not obvious and the aircraft should have an artificial stall warning device installed.

The CASA review of Lancair aircraft also included a desktop assessment by the CASA test pilot of the aircraft's generic flight characteristics. This assessment included the following points:

- The Lancair was a high-performance aircraft optimised for high-speed cruise. Its low-speed handling characteristics were, therefore, sensitive. The aircraft had crisp, well-harmonised controllability characteristics, overlaid on positive, though generally weak stabilities.
- Stall speeds were generally higher than those of general aviation aircraft of similar weights.
- Stall characteristics were generally benign and repeatable, although high rates of descent may occur.

- The natural stall warning was limited, and artificial stall warning devices were recommended.
- Aircraft stability and stall characteristics became worse as the centre of gravity moved aft. The rear centre of gravity limit was often determined by the handling characteristics becoming unsatisfactory.
- Control forces around the pitch and roll axes were light but well harmonised. Rudder forces were relatively high but acceptable. Manoeuvre stability was a little light, but satisfactory. (The actual manoeuvre stability was less than that required for an aircraft certified in the utility category).
- The Lancair generally exhibited positive, but light, static longitudinal stability. One reference noted a considerable weakening of longitudinal stability as the centre of gravity moved aft.

Air Traffic Control information

At the time of the accident, the aircraft was in the Archerfield control zone, and under the control of the Archerfield Aerodrome Controller.

Civil Aviation Regulation (1988) 224 stated that the pilot in command of an aircraft was responsible for the operation and safety of an aircraft during flight, and that s/he had the final authority on the disposition of the aircraft. Further, the Aeronautical Information Publication GEN 3.3 2.1.1 stated that pilots were 'responsible for requesting information necessary to make operational decisions'.

The Manual of Air Traffic Services (MATS) 2.1.1 stated that the objectives of the air traffic services were to:

- prevent collisions
- maintain an orderly flow of traffic
- provide advice and information useful for the safe and efficient conduct of flights
- notify emergency response organisations when required.

MATS 5.1.1 stated that the provision of air traffic control services (that is, the prevention of collisions) was a higher priority than the provision of flight information services, and that nothing in MATS should prevent air traffic controllers from exercising their best judgement and initiative in assisting pilots when the safety of an aircraft may be considered to be in doubt.

Neither of the two controllers on duty in the Archerfield control tower saw the aircraft. The control tower was fitted with a traffic situational awareness display (TSAD) that depicted radar information. The controllers were aware of the aircraft's position relative to the airport by monitoring the TSAD. The TSAD was not approved for use in separating aircraft or in providing navigation assistance. Assistance with navigation, using the Airservices radar system was available through the Brisbane Radar Controller, as advised to the pilot by the Archerfield controller. There was no evidence that the pilot contacted the Brisbane Radar Controller, nor did he advise that he was a non-instrument-rated pilot operating in IMC.

The controller did have a duty of care to provide information to assist the pilot to conduct the flight safely. The controller suggested a direction of turn in response to the pilot's advice that he thought he had overflown Archerfield. The controller also alerted the pilot to the fact that his aircraft appeared to be very low.

Amateur-built aircraft operations

Issues related to the operation of experimental aircraft over populated areas were considered during the investigation of the fatal accident involving Lancair 360, VH-ZNZ, which occurred at Bankstown airport, NSW, on 5 April 2006[16]. The following information has been taken from that report.

> The occurrence of two fatal Lancair accidents in densely populated areas within five days of each other prompted the ATSB to review of the operation of amateur-built aircraft in Australia.
>
> In the Australian regulatory context, an amateur-built aircraft is defined as an aircraft the major portion of which has been fabricated and assembled by a person that undertook the construction project solely for the person's own education or recreation. In 1998, the Civil Aviation Safety Authority (CASA) introduced an experimental aircraft designation, which allowed the design, building, operation and maintenance of a variety of amateur-built aircraft in a similar way to the US. Prior to 1998, only CASA-approved aircraft designs were allowed to be amateur-built and CASA monitored each stage of the construction process.
>
> CASA or its delegate must issue an experimental certificate to an aircraft, but is required to impose conditions that are considered necessary for the safety of other airspace users and persons on the ground or water. There is no provision for CASA or its delegate to impose conditions to safeguard the pilot or passengers.
>
> Accordingly, a placard is required in experimental aircraft that states:
>
> 'Warning Persons fly in this aircraft at their own risk. This aircraft is not operated to the same safety standards as a normal commercial passenger flight CASA does not set airworthiness standards for experimental aircraft.'
>
> An experimental certificate is not a certificate of airworthiness. Amateur-built aircraft do not have to comply with any recognised airworthiness standards including crashworthiness standards. CASA does not take any responsibility for the airworthiness of an experimental aircraft, which is the responsibility of the builder or subsequent owner.
>
> CASA delegates the issuance of experimental certificates to specific individuals who are called authorised persons (APs). An AP is typically a Licensed Aircraft Maintenance Engineer (LAME) with extensive aviation experience. They are provided with training and are required to follow a documented process for assessing airworthiness to the extent required for issuing a certificate. CASA audits the AP processes and experimental certificates issued by APs.

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16 ATSB Accident investigation report 200601688, available at http://www.atsb.gov.au.

Although an aircraft such as a Lancair 320 is built from a kit, the experimental designation allows a builder to make changes to the design, materials and construction technique. As a result, a completed amateur-built aircraft is considered to be a unique aircraft that may have individual operational characteristics.

Before an experimental certificate is issued, an AP will inspect the aircraft and assess its conformance to the applicable administrative requirements and its airworthiness in regard to the safety of other parties. The AP will issue an experimental certificate that only allows flight testing within a specific geographic area that is not densely populated. The flight testing period may be 25 flight hours for aircraft using a type-certificated engine/propeller combination, or 40 flight hours for a non-certificated engine/propeller combination. A number of other conditions will usually be imposed.

Once the flight testing period is complete and the owner has certified that the aircraft is controllable and has no hazardous operating characteristics or design features, the limitations related to the flight testing will usually be removed. Specific authorisation is required to operate an experimental aircraft over the built-up area of a city or town. An aircraft of a proven design built from aviation grade materials and fitted with a certified engine and propeller will typically be granted that authorisation.

If an experimental aircraft is VH-registered, the minimum pilot qualification is a CASA-issued private pilot's licence with the appropriate endorsements. An experimental aircraft must be operated in accordance with the rules and regulations that apply to certified VH-registered aircraft. A maximum of five passengers may be carried provided each person is informed that the design, manufacture and airworthiness of the aircraft is not required to meet any CASA standards and that they fly in the aircraft at their own risk.

The owner-builder of an experimental aircraft is authorised to perform and certify maintenance on that aircraft, or may contract a LAME. Subsequent owners are required to use a LAME or else obtain a maintenance authority to maintain their aircraft.

The owner-builder of an amateur-built aircraft is able to sell the aircraft to any person. The new owner (and any subsequent owner) of the aircraft is entitled to operate the aircraft in accordance with the original experimental certificate.

The Sport Aircraft Association of Australia Inc (SAAA)[17] is 'an active group of aviation enthusiasts supporting one another in building and flying recreational aircraft'. The SAAA provides a Flight Safety Assistance Program, which currently has three active modules covering building, test flying and maintaining amateur-built aircraft. A fourth module, a generic pilot proficiency program is planned.

A call by the SAAA for Lancair pilots/owners to form a Lancair expert group resulted in a small number of suitable persons being put in contact with each other. The SAAA coordinates all but two of the APs and has produced a standard manual of operating procedures. The SAAA has issued revised guidance material to its APs in the latest revision to the AP manual following the two most recent fatal Lancair accidents.

17 Information on the Sports Aircraft Association of Australia is available at http://www.saaa.com.

Other information

Fatal Lancair accidents

On 5 April 2006, 5 days after the accident involving BST, an amateur-built Lancair 360 collided with terrain at Bankstown Airport, NSW, fatally injuring the pilot. The ATSB's final report on this accident was released on 21 February 2007, and concluded that the aircraft stalled after a partial engine power loss, and the pilot did not recover control in the height that was available.

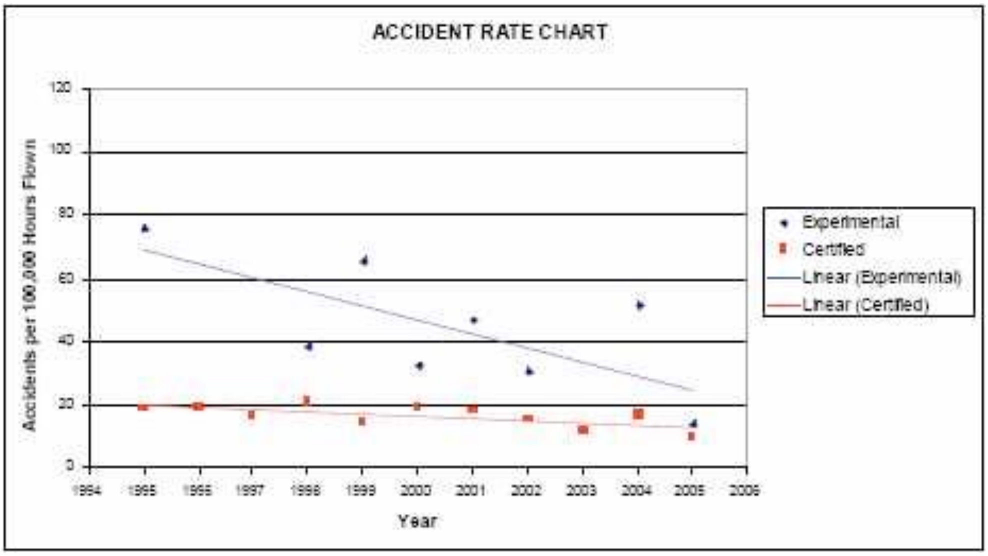
Including the two fatal amateur-built Lancair accidents in 2006, there have been seven fatal Lancair accidents in Australia. In each accident, the circumstances indicated uncontrolled flight into terrain following a stall, or a stall and spin. Three of these accidents involved engine power loss. More details regarding these accidents can be found in ATSB report 200601688, Engine power loss – Bankstown Airport – 5 April 2006 – VH-ZNZ – Amateur-built Lancair 360.

Experimental aircraft accident rate

In 2006, following the two fatal accidents involving amateur-built experimental aircraft, the ATSB conducted preliminary research into the accident rate for these types of aircraft in Australian operations. The results of this preliminary work indicated that the accident rate for amateur-built aircraft was about 2.5 times greater than for comparable certified fixed-wing single-engine aircraft. However, the relatively low numbers of amateur-built aircraft meant that the resulting statistics were not as reliable, and there was a wide scattering of results. In addition, there were a wide variety of aircraft designs included in this designation.

The annual accident rates between 1995 and 2005 for amateur-built experimental and comparable type-certificated fixed-wing single-engine aircraft indicated that the accident rates for the two aircraft types were converging (Figure 7).

Figure 7: Amateur-built experimental aircraft accident rate chart



The ATSB is currently conducting a study of a range of aspects of amateur-built and experimental aircraft safety as a follow up to the previous work, with the results expected to be published by mid-2008. This study is believed to be the first comprehensive study of the safety aspects of this type of aircraft.

VFR into IMC investigation and research

Aviation safety data show that adverse weather continues to be a significant contributor to the development of aviation occurrences. The following information was taken from ATSB Investigation Report 200505107.

[T]here has been substantive research examining weather-related decision-making amongst pilots.[18, 19, 20, 21, 22, 23] Various training tools, which have been developed by researchers to facilitate better weather-related decision-making, have also been made available to pilots by CASA.[24] Furthermore, CASA has organised and conducted safety seminars on a regular basis for pilots across Australia. Those seminars have included case studies on weather-related accidents.

A recent ATSB aviation research report (B2005/0127) titled 'General Aviation Pilot Behaviours in the Face of Adverse Weather' examined a set of 491 Australian accident and incident reports involving weather-related decision-making behaviours amongst pilots.[25] Weather-related decision-making behaviours can be defined as those behaviours necessary to recognise and avoid meteorological phenomena that present a hazard to a flight.

The study highlighted the following three primary decision-making behaviours amongst the accident and incident reports examined:

- decisions that resulted in VFR flight into IMC (280 cases), comprising 45 accidents and 235 incidents
- the conduct of a weather-related precautionary landing (60 cases), comprising 14 accidents and 46 incidents
- the decision to carry out some other significant avoidance action (151 cases), comprising 5 accidents and 146 incidents.

The three decision-making behaviour groups identified by the study represent a behavioural continuum that reflects different levels of risk to the safe completion of a flight, with VFR into IMC representing the greatest threat to flight safety. Pilots in the weather-related precautionary landing, or 'weather avoidance' group were distinguished by taking

18 Wiggins, M. W., & O'Hare D. (2003). *Weatherwise: Evaluation of a cue-based training approach for the recognition of deteriorating weather conditions during flight.* Human Factors, 45, 337-345.

19 Wiggins, M. W., & O'Hare, D. (2003). *Expert and novice pilot perceptions of static in-flight images of weather.* International Journal of Aviation Psychology, 13, 173-187.

20 Hunter, D. R, Martinussen, M., & Wiggins, M. (2003). *Understanding how pilots make weather-related decisions.* International Journal of Aviation Psychology, 13, 73-87.

21 Wiggins, M. W. & O'Hare, D. (1995). *Expertise in aeronautical weather-related decision-making: A cross-sectional analysis of general aviation pilots.* Journal of Experimental Psychology: Applied, 1, 305-320.

22 Batt, R., & O'Hare, D. (2005). *Pilot behaviors in the face of adverse weather: A new look at an old problem.* Aviation, Space, and Environmental Medicine, 76, 552-559.

23 O'Hare, D., & Smitheram, T. (1995). *"Pressing on" into deteriorating conditions: an application of behavioural decision theory to pilot decision making.* International Journal of Aviation Psychology, 5, 351-370.

24 See http://www.casa.gov.au. For example, Weather Wise CD, Weather to Fly DVD, In-Flight Decision Making CD.

25 The cases included fixed-wing general aviation occurrences but excluded night VFR flights, sport aviation, and aerial work such as agricultural flying.

> timely action before the mid-point of the flight. Seventy six percent of the VFR flight into IMC accidents involved a fatality, significantly greater than the fatality rate for other types of general aviation accidents. The chances of a VFR into IMC encounter increased as the flight progressed until reaching a maximum during the final 20% of the flight distance. This result highlights the danger of pilots 'pressing on' to reach their destination.

The NTSB recently conducted research into weather-related general aviation accidents, subsequently publishing a report titled 'Risk factors associated with weather-related general aviation accidents'.[26] This research compared accident flights that occurred in conditions characterised by instrument meteorological conditions or reduced visibility, with flights that did not result in accidents but which were operating at around the same time and in the same geographic vicinity as the accident flights, and were therefore likely to have been operating in similar meteorological conditions. The results of that research identified flight characteristics that contribute to the occurrence of accidents, which could be broadly grouped into areas of recommended approaches that could be used to reduce the risk of weather-related accidents.

Effects of fatigue

Fatigue in aviation is a recognised problem that has been associated with many air safety occurrences[27].

The negative effects of fatigue on human performance are wide-ranging. For example, it can affect flight crew performance in areas such as reaction time, attention, memory, and decision making.

An increase in reaction time can lead to timing errors, less smooth control, and the need for stronger stimuli to gain the pilot's attention. A decrease in attention can result in mistakes in task sequences, preoccupation with particular tasks, and a reduced audiovisual scan. Diminished memory can lead to inaccurate recall of operational events, forgetting to carry out peripheral tasks, and reversion to established routines[28].

Fatigue can have a detrimental effect on decision making by increasing the time it takes for a pilot to take in and interpret information. Hence, their ability to accurately perceive the situation they face, and take appropriate and timely action, can be diminished[29].

When fatigued, a pilot's performance is likely to become increasingly inconsistent. Another insidious aspect of fatigue is that the pilot is likely to be unaware of the extent to which their performance has been negatively affected.

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26 NTSB/SS-05/01

27 Caldwell JA & Caldwell JL (2003). *Fatigue in aviation: A guide to staying awake at the stick.* Hants, UK: Ashgate.

28 Graeber RC (1988). Aircrew fatigue and circadian rhythmicity. In EL Wiener and DC Nagel (Eds.) *Human Factors in Aviation*. San Diego: Academic Press.

29 Costa G (1999). Fatigue and biological rhythms. In DJ Garland, JA Wise, & VD Hopkin (Eds), *Handbook of Aviation Human Factors*. Mahwah, NJ: LEA.

Coronial actions

Following a New South Wales Coronial Inquest, conducted from 4 to 6 December 2007, into a the death of the pilot of a Lancair at Bankstown Airport, NSW, the Coroner, Mr McMahon made the following recommendation:

> CASA to consider the default position of fitment of angle of attack/stall warning devices to experimental aircraft except in those cases were it is considered unwarranted for good reasons.

ANALYSIS

Introduction

The circumstances of the accident indicate that the pilot lost control of the aircraft at a height from which it was not possible to recover, resulting in uncontrolled flight into terrain. The loss of control was consistent with an aerodynamic stall, followed by the aircraft entering a spin to the left prior to impact. The loss of control occurred when the aircraft was operating in adverse weather conditions, at a low height above the ground, and tracking towards an area of reduced visibility and terrain that was higher than the aircraft.

One witness's description of the loss of control was consistent with an aerodynamic stall of the left wing during a turn to the right. Another witness's description was consistent with a stall of the left wing during level flight. The estimated airspeed of the aircraft at the time of the loss of control, based on radar-derived groundspeed, was well above the unaccelerated stalling airspeed. Therefore, it is likely that an accelerated manoeuvre stall occurred, which is consistent with the report of the loss of control occurring during a turn, or could have been the result of some other application of the flight controls which increased the load factor such that the stall speed increased above the true airspeed. The physical evidence at the accident site indicated that the aircraft was spinning to the left when it collided with trees and the ground.

Various aspects of the event increased the risk of an accident occurring. These aspects and their contribution to the development of the accident are considered in the following paragraphs.

Weather

The existing weather conditions, and the pilot's decision to continue flight to Archerfield in non-visual meteorological conditions (VMC), reduced the safety of the flight.

The pilot had obtained and reviewed the weather forecast, and therefore should have been aware of the adverse weather conditions forecast for Archerfield. The forecast weather conditions were consistent with the actual weather conditions on the day. The reported weather conditions, weather observation records and weather radar information indicated that it was unlikely that the aircraft was in visual meteorological conditions when the aircraft was approaching Archerfield. By continuing the flight to Archerfield, even though it was unlikely that the aircraft could remain in VMC for the remainder of the flight, the pilot increased the risk of a weather-related accident. Accidents involving VFR flight into IMC have a higher fatality rate in comparison with other accident types.

The Archerfield Terminal Area Forecast did not require the pilot to plan for an alternate airport as long as the aircraft had sufficient fuel for 30 minutes holding. The aircraft reached the airport with enough fuel for 30 minutes holding if required. Despite not requiring an alternate airport, the pilot had discussed diverting to an alternate with the flying school manager at Townsville prior to departure, and there were many airports that were potentially available between Townsville and Archerfield to which he could have diverted.

The weather radar data indicated that at the time of the accident, the aircraft was tracking toward an area of rain, and therefore reduced visibility, north-east of Archerfield. Witness information indicated that there was low cloud on the tops of the hills north and north-east of the accident site. The aircraft was probably clear of cloud once it had descended to about 500 ft; however it was unlikely that the pilot had 5 km visibility. The reduced visibility ahead of the aircraft would have made it more difficult for the pilot to discern the horizon. After the aircraft had passed its destination, the low cloud and reduced visibility ahead of the aircraft would have increased the pressure on the pilot to act in order to prevent the aircraft from re-entering cloud and/or rain.

The low cloud reduced the pilot's ability to maintain the aircraft at a safe height above terrain, and the reduced visibility in rain obscured the horizon and the relatively high terrain ahead of the aircraft. It is unlikely that the accident would have occurred in fine weather, and therefore, the adverse weather conditions were a contributing safety factor to the development of the accident.

Aircraft

The amateur-built Lancair 320 aircraft exhibited flying and handling characteristics which increased safety risk in comparison with most certified aircraft. In addition, issues related to the equipment fitted to the aircraft also increased safety risk.

The Lancair was fast in comparison with the aircraft the pilot was more familiar with, which meant that situations could develop more rapidly than he was used to. As such, he may have felt rushed when dealing with the compounding events of operating in an unfamiliar geographical and airspace environment, adverse weather conditions, complying with unfamiliar procedural requirements, not locating his destination airport, and then having to develop an alternative course of action.

The control characteristics of the Lancair made it easier to input, and more difficult to recognise, an inadvertent or inappropriately excessive application of the flight controls. Light control stick forces increased the risk of a flight control-induced accelerated aerodynamic stall.

The builder of BST reported that the aircraft exhibited a tendency to roll without pilot input to correct any uncommanded roll deviations. This report was consistent with stability characteristics reported by test pilots following flight tests of amateur-built Lancair aircraft. This tendency increased the risk that a pilot focussing on other flight management tasks may not notice the aircraft rolling in time to prevent the bank angle increasing to that at which an accelerated stall would occur.

The aircraft was not fitted with any instruments which used ground-based navigation aids for position information. Although such instruments may not provide as much information as advanced electronic navigation instrumentation, they are simple to use and relatively easy to interpret.

The lack of a functioning artificial stall warning system reduced the pilot's ability to recognise the onset of, and prevent, an aerodynamic stall, and increased the risk of the pilot losing control. The aircraft builder, other Lancair owners and pilots, and the Civil Aviation Safety Authority (CASA), generally considered that the

Lancair's natural stall warning was insufficiently obvious to alert a pilot to an imminent stall, and that Lancair aircraft should be fitted with an artificial stall warning device. The angle of attack indicator that was fitted to BST, had it been functional, would have provided a more effective indication of the imminence of aerodynamic stall, given that it constantly provided either visual, or visual and aural indications of the angle of attack. Pneumatic stall warning devices generally provide an aural warning just prior to, at and above the stalling angle of attack.

The Lancair 320 aircraft lost relatively significant height following an accelerated aerodynamic stall. Therefore, stalls in this aircraft required substantial height above terrain to allow the pilot sufficient time to recover control.

The radar data showed that the aircraft stalled well above the normal stalling airspeed. This accelerated stall most likely occurred either because of the application of the flight controls (either inadvertent or excessive) and/or because the aircraft reached a bank angle at which either one or both of the wings reached the stalling angle of attack and stalled. The information available does not allow the investigation to determine which scenario occurred, and therefore it is not possible to establish either the light control stick forces, or the aircraft's stability characteristics as a contributing safety factor. The angle of attack indicator installed in the aircraft, but not calibrated or connected, would likely have provided a salient warning of the imminent aerodynamic stall had it been functioning. Therefore, the absence of this safety defence is considered a contributing safety factor. The pilot was more likely to have recognised a stall in an aircraft with a more obvious natural stall warning, and therefore this aircraft characteristic is considered to be a contributing safety factor. The height lost by the Lancair aircraft type following an accelerated stall was considered a contributing safety factor.

Training

The pilot held the appropriate pilot's licence and special design feature endorsements to operate the Lancair.

The pilot completed transition training on the Lancair aircraft. However, the lack of flight training records related to that training limited the investigation's ability to assess its comprehensiveness. Civil Aviation Order (CAO) 40.1.0 section 4.4 required that the pilot be familiar with the aircraft normal and emergency flight manoeuvres, and have sufficient training and recent experience on the aeroplane type, or a comparable type.

Based on another pilot's experiences with the instructor, it is likely that the accident pilot did not observe or experience an incipient aerodynamic stall, a full stall, or stall recovery in the Lancair. The instructor reportedly held the view that it was impossible to recover from a stall in this type of aircraft. Therefore, it is unlikely that the pilot had been shown or experienced the onset of an aerodynamic stall and the natural buffeting associated with the onset of a stall in the Lancair. Consequently, the pilot's ability to recognise the buffeting associated with the aircraft's natural stall warning, and to recover from a stall was reduced. Practicing relatively high risk manoeuvres such as stalls in Lancair 320 aircraft may not provide an overall increase in safety, and a clear safety benefit should be established prior to the conduct of higher risk manoeuvres. Alternative means of instruction such as ground-based training should be considered if the safety risk of in-flight demonstrations was considered to outweigh the benefit. It is not clear whether the instructor provided ground training in stall recognition and recovery.

The pilot increased safety risk in not slowing the aircraft by establishing it in a bad visibility configuration. Had he done so, he would have reduced the speed at which the aircraft was moving away from his destination airport, and with flap extended, he would have reduced the aerodynamic stall speed. It is probable that the pilot did not undergo low level navigation or precautionary search and landing training in the Lancair. It could not be determined whether the accident pilot was shown how to establish the Lancair in a bad visibility configuration.

The pilot completed stall and bad visibility configuration training during his training for a private license, but these exercises were conducted in aircraft with substantially different handling and aerodynamic characteristics to the accident aircraft.

There was no specific guidance included in the CAO regarding which emergency flight manoeuvres should be included in transition training, or how a pilot should develop familiarity with those manoeuvres. The investigation considered that the provision of formal guidance as to how to comply with the CAO 40.1.0 section 4.4 requirements could emphasise the need for a risk-based approach to a pilot's transition to new aircraft types and provide the means for pilots and instructors to develop appropriate ground and flight training.

There was no evidence that the pilot complied with the instructor's recommendation that he undertake further flying with a safety pilot prior to operating the aircraft on his own. It is unclear what factors led the instructor to form the view that the pilot required additional oversight. However, these factors may have included the pilot's overall lack of flying experience and his inexperience in operating high performance aircraft with the flying characteristics of the Lancair.

It is unclear whether additional training in stall recognition and avoidance in the Lancair or establishing the aircraft in a bad-visibility configuration would have significantly reduced safety risk. On this basis, these factors cannot be identified as contributing to the development of the accident. The lack of comprehensive risk-based transition training guidance, and the pilot's failure to complete additional flying under supervision also increased safety risk.

Navigation

The pilot was probably using the one of the portable GPS units and the panel-mounted GPS to provide navigation information. The portable GPS was observed by the flying school manager on top of the glareshield and that unit's location at the accident site suggested it was in that position at the time of the accident. The pilot's only available sources of position information were the GPS units and visual references.

It is not clear whether the pilot saw Archerfield Airport, but failed to identify it due to a lack of familiarity with its appearance, or whether low cloud and precipitation prevented him from seeing the airport at all. The fact that the controllers did not see the aircraft suggests the pilot did not see the airport due to cloud and/or reduced visibility at the time.

Reduced visibility and unfamiliarity with the area would have reduced the effectiveness of visual references for navigation purposes. The GPS indications of direction to the destination may not have been as obvious as other navigation systems which were not installed in the aircraft. This would have been even more evident after the aircraft passed the destination, at which time the GPS units may not have provided clear position information relative to the airport.

Both the portable and panel-mounted GPS units could have been manipulated to provide navigation assistance from the aircraft's present position direct to Archerfield Airport after the aircraft had passed its destination. However, to set up the units to provide this assistance required a sequence of at least five discrete button pushes and dial rotations. The focus of attention required to complete these actions would have reduced the pilot's ability to maintain his awareness of the speed and attitude of the aircraft, and its position relative to terrain and adverse weather.

Although the pilot's inability to identify Archerfield did not directly contribute to the development of the accident, it would have significantly increased the workload in the cockpit, as the pilot sought to determine the most appropriate course of action. This workload may have affected the pilot's ability to maintain control of the aircraft and monitor the terrain and weather conditions towards which the aircraft was flying.

Loss of control

After the aircraft passed Archerfield, the pilot was faced with a rapidly deteriorating situation. Ahead of him was adverse weather, including low cloud and rain, resulting in a significant degradation in forward visibility. In addition, the aircraft was at a very low height, and the pilot was not familiar with the terrain or obstacles ahead of the aircraft. In this context, it would have been difficult for the pilot to collect the information that was available to him, consider potential options, and decide on the most appropriate course of action.

The aircraft was below the level of terrain and obstacles a few kilometres ahead of the aircraft. The reduced visibility would have made it difficult for the pilot to visually acquire the approaching terrain and obstacles; however, given his close proximity, he may have seen the terrain in front of the aircraft and been responding by attempting to manoeuvre the aircraft when he lost control.

Alternatively, the portable GPS with the terrain warning feature may have alerted the pilot to an imminent collision with terrain, an alert the pilot may not have been expecting. A large control input intended to rapidly direct the aircraft away from the terrain in response to a sudden and unanticipated terrain alert could have precipitated an aerodynamic stall and loss of control.

The amateur-built Lancair aircraft's inherent stability and control characteristics increased the risk of the pilot losing control. The right bank that was observed could have been the result of a deliberate control application by the pilot, or developed as a result of the pilot focusing his attention on another task. In the situation that faced the pilot, there were a number of potential tasks that he could have focused on, including attempting to identify ground features in order to locate the position of the aircraft, manipulating the GPS units to identify the direction to Archerfield, avoiding the poorer weather conditions that the aircraft was flying towards, reacting to the terrain in front of the aircraft becoming visible, or responding to a GPS terrain alert.

Amateur-built aircraft operating over built-up areas

The amateur-built status of the accident aircraft resulted in it having characteristics that would not have been permitted in a fully certified aircraft, and those characteristics increased the risk of the pilot losing control.

The control dynamics of the aircraft did not meet the standards of certified aircraft of comparable weight and performance. In comparison with the Lancair, certified aircraft had greater feedback through the control column regarding the degree of control deflection, and therefore a reduced risk of pilot-induced oscillations and an overcontrolling-induced loss of control. Similarly, a certified aircraft with an inadequate natural stall warning was required to have an artificial stall warning system, which may have allowed the pilot to recognise the onset of an aerodynamic stall in sufficient time to prevent the stall from occurring.

The authorised person who issued the experimental certificate included a condition on that certificate which was intended to reduce the risk of collision between the aircraft and persons or dwellings following an engine failure. The condition required the pilot to avoid flight over persons and dwellings to the greatest extent possible. There was no condition on the certificate which was intended to reduce the risk of the aircraft colliding with persons or dwellings following a loss of control, even though the aircraft characteristics increased the risk of a loss of control event in comparison with comparable certified aircraft.

Other issues

Engine failure

The investigation considers that the engine was most likely operating normally at the time of the accident. Although one witness reported hearing the aircraft engine noise stop prior to the accident, a witness closer to the aircraft said that he heard steady engine noise, with no indication of engine failure. The examination of the wreckage identified evidence that the engine was delivering power to the propeller at the time of the accident.

Air Traffic Control

At the time of the occurrence, the pilot was in the Archerfield control zone, and under the control of the Archerfield Aerodrome Controller. Regardless of the use of the term ‘control’, the ultimate responsibility for the conduct of the flight rested with the pilot. Although there may be some occasions where it is appropriate for a controller to direct the conduct of some aspects of a flight, ultimately the pilot is in the best position to make decisions and operate the aircraft.

The Archerfield controller’s suggestion that the pilot continue his left turn in order to proceed to the airport was a potentially inappropriate use of the information available on the traffic situational awareness display. However, the controller had a duty of care to assist the pilot by providing information and in the circumstances, it was reasonable for him to respond to an apparently high-risk situation by assisting the pilot to locate and return, to the airport.

Antidepressant usage

The established effects of anti-depressant medication suggest that the pilot's use of the anti-depressant fluoxetine did not play any role in the development of the accident. Although fluoxetine has been found to impair judgement, thinking and motor skills, these effects are generally noted to be evident shortly after a patient commences treatment, and the effects generally reduce as a patient becomes physiologically accustomed to the medication. The pilot had been taking fluoxetine for more than 10 years at the time of the accident, more than sufficient time for adverse effects to have been noted and for him to be physiologically accustomed.

Fatigue

While some of the pilot's actions might be considered as indicators of fatigue the investigation was unable to establish the degree to which fatigue may have been a factor in the accident.

Conclusion

The pilot lost control of the aircraft at a height from which it was not possible to recover, resulting in uncontrolled flight into terrain. The aircraft impacted terrain in a nose-down attitude and spinning to the left. The severity of the impact meant that the accident was not survivable. The loss of control was consistent with an accelerated aerodynamic stall, followed by the aircraft entering a spin to the left prior to impact. The loss of control occurred when the aircraft was operating in adverse weather conditions of low cloud, at a low height above the ground, and tracking towards an area of reduced visibility in rain and terrain that was higher than the aircraft.

The pilot's decision to continue the flight into instrument meteorological conditions, even though neither he nor the aircraft were certified to operate is those conditions, increased safety risk. The pilot's ability to fly the aircraft and manage the flight was limited by his relative lack of experience on high performance aircraft, and deficiencies in the training that he had received on the Lancair. Aspects related to the aircraft's equipment also increased safety risk.

Some aerodynamic and flight control characteristics of the Lancair 320 aircraft increased the risk of an accident. However, those characteristics were largely a consequence of the mission for which the aircraft had been designed. In order to operate Lancairs and other high-performance amateur-built experimental aircraft safely, pilot's need to be aware of, and maintain the aircraft within, the safe operational envelope.

FINDINGS

From the evidence available, the following findings are made with respect to the loss of control involving Lancair 320 aircraft VH-BST on 31 March 2006 and should not be read as apportioning blame or liability to any particular organisation or individual.

Contributing Safety Factors

- The pilot continued flight into instrument meteorological conditions, when neither he nor the aircraft were rated for operations in those conditions.
- The angle of attack indicator in the aircraft was not operational at the time of the accident.
- The natural stall warning was probably not sufficiently obvious to alert the pilot that the aircraft was approaching an aerodynamic stall.
- The aircraft stalled and the pilot lost control of the aircraft at a height from which recovery was not possible.
- The aerodynamic characteristics of the aircraft meant that it needed substantial height to recover from an accelerated aerodynamic stall.

Other Safety Factors

- The pilot's transition training on the aircraft did not include familiarisation with the indications of an incipient accelerated aerodynamic stall.
- The pilot did not locate the destination airport.
- After the aircraft passed the destination airport, the pilot's attention was probably focused on locating the airport.
- The pilot did not configure the aircraft for flight in reduced visibility.
- At the time of the loss of control, the aircraft was tracking towards, and within 5 km of, terrain that was higher than the aircraft, and towards an area of reduced visibility in rain.
- The light control stick forces of the aircraft increased the risk of overcontrolling the aircraft, or inadvertent flight control deflection.
- The stability characteristics of the aircraft required increased pilot vigilance to monitor and maintain the desired aircraft attitude.

Other Key Findings

- The aircraft was serviceable at the time of the accident, with no defects that could have contributed to the development of the accident.
- The forecast weather conditions were consistent with the observed weather at the time of the accident.
- The Archerfield Aerodrome Controller's attempts to assist the pilot were very unlikely to have contributed to the development of the accident.

SAFETY ACTION

Previously reported safety action

The safety action statement below from the Civil Aviation Safety Authority and the Sport Aircraft Association of Australia is from the Australian Transport Safety Bureau's investigation report (200601688 released 21 February 2007) into the fatal accident involving Lancair aircraft, registered VH-ZNZ, that occurred at Bankstown Airport, NSW on 5 April 2006. The following safety action was in response to both the Bankstown and the Archerfield Airport Lancair accidents.

Civil Aviation Safety Authority

As a result of the two recent fatal accidents involving amateur-built experimental Lancair aeroplanes, the Chief Operating Officer (COO) requested a review of Lancair operations be undertaken. A review panel comprising a number of Civil Aviation Safety Authority (CASA) staff and an industry representative was formed. The review panel produced a report and made the following three recommendations to the CASA COO:

- That an article be published in Flight Safety Australia
- That guidance material for transition and recurrent training be developed for flight crew of high performance experimental aircraft
- That guidance material on risk assessment and mitigation be developed for authorised persons to ensure third party risks are appropriately considered when issuing an experimental certificate.

At the time of writing the report CASA advised that the following safety action had been undertaken in response to the Lancair review panel recommendations:

- An article 'Slick Singles' about new generation aircraft was published in the November-December 2006 edition of the Flight Safety Australia magazine.
- CASA's view is that a Civil Aviation Advisory Publication for Civil Aviation Order 40.1.0 section 4.4 may not be required. However, the development of some guidance material may be worthwhile and the Australian Transport Safety Bureau (ATSB) was invited to provide input to the next Flight Training Industry Development Panel meeting.
- Guidance material on risk assessment and mitigation in regard to the issuing of experimental certificates had been developed and was being progressively delivered to authorised persons.

The ATSB presented the safety issues identified by the investigation to CASA. At the time of writing the report CASA advised the following:

- The CASA Flight Instructor Manual – Aeroplane, was revised and re-issued in December 2006 with increased emphasis on engine failure on take off considerations and in particular aeroplane control, partial power loss and turn back.

- CASA is considering developing an Evening Safety Seminar presentation on engine failure after take off and emergency procedures. Once developed, this would be delivered to pilot groups by CASA Field Safety Advisors on request.
- A change to the *Day VFR Syllabus – Aeroplanes* was feasible, but would involve considerable work by CASA to not only change the syllabus but promote it to industry.
- CASA has written to authorised persons advising them to consider the fitment of stall warning devices.

Sport Aircraft Association of Australia

The ATSB presented the relevant safety issues identified by the investigation to the Sport Aircraft Association of Australia (SAAA) and understand that the following actions are planned:

- Review of the guidance given to authorised persons affiliated with the SAAA in regard to stall warning characteristics and other airworthiness features when applying operating limitations
- Cooperating with the insurance industry to form a 'Lancair breed group' and produce an aircraft familiarisation syllabus for high performance aircraft.

Australian Transport Safety Bureau

Following two fatal accidents in 2006 involving Lancair aircraft and the increasing number of amateur-built/experimental aircraft appearing on the Australian aircraft register, the ATSB's Aviation Safety Research and Analysis section initiated a study to examine the relative safety of amateur-built/experimental aircraft. A survey of owner/builders of currently flying civil-registered amateur-built/experimental aircraft was conducted in 2007 to ascertain the background of these operators and the processes used to build and test their aircraft. The project will also compare the accident record of civil-registered amateur-built/experimental aircraft with that of similar performance certified/factory built aircraft. The analysis of these data is currently occurring and the report is expected to be published in late 2008.