



Australian Government

Australian Transport Safety Bureau

ATSB TRANSPORT SAFETY INVESTIGATION REPORT

Aviation Occurrence Report – 200505236

Final

Aircraft loss of control - Ballidu, WA

22 October 2005

VH-NIT

Air Tractor Inc AT-602



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Postal address: PO Box 967, Civic Square ACT 2608
Office location: 15 Mort Street, Canberra City, Australian Capital Territory
Telephone: 1800 621 372; from overseas + 61 2 6274 6440
Accident and incident notification: 1800 011 034 (24 hours)
Facsimile: 02 6247 3117; from overseas + 61 2 6247 3117
E-mail: atsbinfo@atsb.gov.au
Internet: www.atsb.gov.au

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Abstract

At about 1425 Western Standard Time on 22 October 2005, an Air Tractor AT-602 aircraft, registered VH-NIT, impacted terrain approximately 100 metres south of the perimeter fence of Ballidu aerodrome, WA. The pilot was carrying out a series of familiarisation flights. He was the sole occupant of the aircraft and was fatally injured.

Witnesses recalled that the aircraft had dropped a quantity of water at low level over the aerodrome. Soon after that drop, the nose of the aircraft pitched steeply towards the ground and the aircraft descended into terrain.

The aircraft impacted terrain in a slightly right wing-low, almost nose-level attitude at a high vertical rate of descent, but with low forward speed.

Examination of the wreckage did not identify any anomaly that could have affected the normal operation of the aircraft during the accident flight. Examination of the engine indicated that it was producing power at the time of terrain impact.

Toxicology testing revealed that the pilot had ingested cannabis. Specialist medical advice was that the results of the toxicology testing would be consistent with the pilot using cannabis sometime during the 24 hours prior to the accident.

The physical and witness evidence was consistent with the pilot losing control of the aircraft at low altitude, most probably as the result of an inadvertent aerodynamic stall. There was insufficient altitude to recover the aircraft to level flight.

THE AUSTRALIAN TRANSPORT SAFETY BUREAU

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.

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 about 1425 Western Standard Time¹ on 22 October 2005, an Air Tractor AT-602 (AT-602) aircraft, registered VH-NIT, impacted terrain approximately 100 metres south of the perimeter fence to Ballidu Aerodrome, WA. The pilot, the sole aircraft occupant, was fatally injured. Impact forces substantially damaged the aircraft.

The pilot had not operated the AT-602 aircraft type prior to the day of the accident and was conducting a series of solo flights to familiarise himself with the handling characteristics of the aircraft under the supervision of the company owner/chief pilot. Because the aircraft was equipped with a single control seat, the chief pilot used a hand-held very high frequency (VHF) radio to communicate as necessary with the pilot.

The first of the series of flights² included ground taxiing operations, takeoffs and landings, and general aircraft handling. That included the pilot carrying out simulated spray runs along the airstrip and practice operating the aircraft's hopper³ door. The pilot landed the aircraft and taxied to the operating pad a number of times during that flight.

The chief pilot reported that he was satisfied with the way the pilot was operating the aircraft and that, when necessary, he had operated equipment on the ground to replenish the contents of the hopper with about 200 L of water. That was the minimum quantity necessary to prevent the hopper's seals from drying out.

The chief pilot recalled the pilot to the operating pad and the aircraft was shut down. The pilot was reported to have remarked to the chief pilot that, when landing the aircraft, he found that he needed to use 'Beta'⁴.

The chief pilot indicated that, after a break of about 30 minutes, he briefed the pilot on the appropriate starting technique for a hot engine. The pilot completed the subsequent engine start and departed on the second familiarisation flight in the aircraft. During that flight, the chief pilot noticed that the hopper door had not closed after a water drop, and radioed the pilot to land and return to the operating

1 The 24-hour clock is used in this report to describe the local time of day, Western Standard Time (WST), as particular events occurred. Western Standard Time was Coordinated Universal Time (UTC) + 8 hours.

2 For the purpose of this report, each 'flight' commenced with the starting of the aircraft engine and concluded when the engine was shut down.

3 Load-carrying compartment in an agricultural aircraft used for carrying and dispersing chemicals and, in this case, water.

4 Beta refers to a mode of engine operation where the propeller blade is operating at fine blade angles, during which the propeller blade angle (and consequently thrust) is directly controlled by movement of the power lever. In this operating range, the propeller does not operate at a constant speed and propeller blade angle and fuel flow are coordinated according to the power lever position. The Beta operating range extends from just below flight idle on the power lever, through ground idle and reverse thrust.

pad. At the pad, the chief pilot manually closed the hopper door and replenished the contents of the hopper. Although the chief pilot did not physically check the quantity of water added to the hopper during that replenishment, the filling time did not give him any impression that an unusually large quantity of water had been added. The chief pilot advised that the hopper load seemed consistent with other flights that day. The pilot taxied from the pad and the chief pilot recalled watching the aircraft take off normally, before turning his attention to other tasks.

Figure 1 depicts the township of Ballidu, the aerodrome, the location of witnesses and the approximate track of the aircraft during the final stages of the flight.

Figure 1: Ballidu townsite and aerodrome, accident site and position of witnesses⁵



Witness information

A number of witnesses at differing positions in the vicinity of the aerodrome (Figure 1) reported either seeing or hearing events associated with different portions of the flight immediately prior to the accident. Those witness reports included from:

- **Position A.** The witness at position A, who was mainly familiar with the operation of piston-engine aircraft, thought that, when compared with other water drops earlier that day, the aircraft's engine sounded as if it was not producing much power as the aircraft started to climb away. The witness reported that, after water was released from the aircraft, the aircraft gained a small amount of height before the nose dropped, and the aircraft descend steeply towards the ground.
- **Position B.** Two witnesses at position B recalled that the water drop lasted for between 1 and 3 seconds, and that the intensity of the water drop appeared to increase as the aircraft flew along the airstrip. They described a 'whoosh' of

⁵ Aerial photograph reproduced by permission of the Department of Land Information, Perth, Western Australia, Copyright Licence 33/2006 www.dli.wa.gov.au

water towards the end of the drop, and that the water falling away from the aircraft looked like clouds. The witnesses reported that, after completing the water drop, the aircraft climbed steeply, before the nose dropped, and the aircraft descended steeply towards the ground.

- **Position C.** The chief pilot, who was located at position C, sighted the aircraft as it climbed out past his hangar and commented that the nose attitude did not appear abnormally high. He did not recall hearing any unusual noises from the aircraft's engine or propeller, and there was nothing about the operation of the aircraft that concerned him. He then saw the nose of the aircraft drop violently, and the aircraft descended steeply towards the ground.
- **Position D.** A witness at position D recalled the aircraft passing abeam that location in a level attitude, before the nose suddenly dropped and the aircraft descended steeply towards the ground. The witness reported that the sound from the aircraft appeared normal and at a constant level until the witness heard the sound of an impact. This witness did not observe the water drop.
- **Position E.** The witness at position E, who was familiar with dropping operations, was watching the aircraft as it approached the aerodrome. Based on the aircraft's position relative to the aerodrome and the location of the runway thresholds, the witness surmised that the pilot was making a practice water drop. The witness reported that the aircraft disappeared from view as it descended to what was perceived to be the drop zone before reappearing. The witness recalled that the aircraft was climbing steeply at that time, but that the nose attitude of the aircraft was close to horizontal, before pitching steeply down towards the ground. An unusual noise was heard from the aircraft's engine or propeller at about the time the aircraft started to descend, which was described as being similar to the noise when a pilot landed and reversed the propeller's pitch, or made a significant change to the power setting of the engine.
- **Position F.** Two residents at position F heard the noise of an aircraft approaching before there was an increase in engine noise, similar to when a pilot applies power to enter a climb, or to the noise made by an aircraft after landing. They recalled a few seconds of silence and thinking that the aircraft must have landed, before hearing the sound of an impact.

An analysis of the information provided by the various witnesses indicated that the aircraft was most probably below 120 ft above ground level (AGL) during the water drop, and at a height of about 150 ft AGL when the nose of the aircraft dropped violently and the aircraft descended steeply towards the ground.

Personnel information

Type of licence	Commercial Pilot (Aeroplane) Licence, issued 05 March 1986 ⁶
Relevant ratings and approvals	Grade 1 Agricultural Rating, issued 08 May 1989 ⁷
Relevant endorsement	Ayers Turbo (PT6), issued 17 October 2005
Flying experience	6,737 hours
Flying experience – turbine	49.3 hours
Flying experience – AT-602	Approximately 1.0 hour ⁸
Flying experience (preceding 30 days)	49.3 hours
Flying experience, fire-bombing operations	389 hours
Medical certificate	Class 1, valid to 05 February 2006, issued without restriction

The pilot had previously performed fire-bombing operations in the operator's piston-engine PZL 'Dromader' M-18 (Dromader) aircraft. The pilot last conducted fire-bombing operations in the Dromader during April 2005.

Regulatory requirements relating to the pilot's experience

Civil Aviation Regulation 5.22 enables the Civil Aviation Safety Authority (CASA) to prescribe the aircraft endorsements that must be held by the holder of a flight crew licence. Civil Aviation Order 40.1.0 requires the holder of a flight crew licence to hold an endorsement to operate certain types of aeroplane, and provides for aircraft with similar design features to be grouped into aircraft classes. The pilot required such an endorsement to operate the AT-602 type aircraft.

The Ayres Turbo (PT6) aeroplane class endorsement includes the Ayres S2R Turbo Thrush (Thrush), and Air Tractor AT 400, 401, 402, 502, 602 and 802 aircraft types that are equipped with a PT6A turbine engine.

Recent experience

The pilot recently completed training for, and was issued with an Ayres Turbo (PT6) aeroplane class endorsement. The pilot's logbook indicated that that training was conducted on 27 September 2005 in a Thrush aircraft, and that the class endorsement was issued on 17 October 2005.

The Thrush was a single-seat agricultural aircraft, which was equipped with a Pratt and Whitney Canada PT6A-15AG⁹ turbine engine, and had a maximum take-off weight of 2,722 kg. Because the aircraft was a single-seat configuration, the endorsing pilot was required to supervise the endorsement training from the ground.

6 The pilot was previously issued a Private Pilot (Aeroplane) Licence on 14 November 1980.

7 The pilot was previously issued a Grade 2 (initial) Agricultural Rating on 04 June 1986.

8 Estimate based on the recorded fuel consumption of the aircraft on the day of the accident.

9 Rated to produce 680 shaft horse power (SHP) at takeoff.

The pilot's logbook indicated that, in the period between 27 September and 5 October 2005, the pilot logged 48.3 hours flying the Thrush. The last recorded flight by the pilot in that aircraft type was on 5 October 2005.

The pilot operated a number of his own aircraft, including a piston-engine Air Tractor AT-401 (AT-401). Consequently, he would have been very familiar with the general control layout and handling characteristics of that aircraft.

72-hour history

It was reported that the pilot's sleep patterns were normal in the days preceding the accident, and that he was well-rested prior to leaving home on the day of the accident.

The pilot lived about 65 km from Ballidu, and was reported to have arrived at Ballidu Aerodrome around mid-morning on the day of the accident. The chief pilot reported that they held an informal briefing on the activities planned for the day, and discussed aspects of the handling and operation of the AT-602. That included a discussion on the wing loading¹⁰ of the AT-602 compared with other aircraft with which the pilot was familiar.

The chief pilot and the operator's operations manager spoke to the pilot prior to and during the flights conducted that day. Both reported that the pilot was in good spirits, and appeared to be his normal self.

Aircraft information

Aircraft history

The AT-602 was designed and manufactured as a single-seat agricultural and fire-fighting (water-dropping) aircraft. The US Federal Aviation Administration (FAA) issued an airworthiness type certificate for the AT-602 as a Restricted Category¹¹ aircraft, for use in special purpose operations. As the certificate was issued by a recognised National Airworthiness Authority, CASA permitted the AT-602 to operate on the Australian aircraft register.

The accident aircraft was manufactured in the US in 2000 and exported to Australia before being placed on the Australian aircraft register in December that year. The aircraft was exported from Australia to New Zealand in April 2002. In December 2004, the aircraft was re-imported to Australia and placed on the Australian aircraft register as VH-NIT.

Since manufacture, the aircraft had accumulated about 1,650 hours total time in service (TTIS).

¹⁰ Wing loading is an expression of an aircraft's operating weight divided by its wing area.

¹¹ The Restricted Category certification was on the basis of the aircraft's compliance with US Federal Aviation Regulation 23, excluding those sections deemed inappropriate for the special purpose uses of agricultural spraying, dusting and seeding and forest and wildlife conservation (fire-fighting).

The last scheduled maintenance carried out on the aircraft was completed on 22 July 2005. The aircraft's maintenance release recorded 58.7 hours operation since that maintenance, and no defects were recorded in that period.

An examination of the aircraft's maintenance documentation showed that all relevant inspections had been carried out, and compliance with relevant service bulletins and manufacturer's specifications for cyclic component limits.

The aircraft was equipped with a 'buddy seat', located immediately adjacent to the pilot's seat. However, that seat was not a conventional crew seating position, and was not equipped with dual controls. Accordingly, the buddy seat was not appropriate for instructional purposes.

Engine and propeller

The aircraft was equipped with a Pratt and Whitney Canada PT6A-60AG¹² turboprop engine. The engine manufacturer recommended a basic operating time between overhaul (TBO) of 3,000 hours, and a hot section inspection (HSI) after 1,500 hours. In addition, cycle limits were specified for other engine components and accessories.

The maintenance records indicated that the engine had accumulated approximately 1,650 hours TTIS since new. An HSI was completed at 1,385 hours TTIS.

The engine was equipped with a five-bladed Hartzell Propeller Inc., HC-B5MP-3C constant speed propeller that was able to be fully-feathered and was reversible in pitch.

The aircraft manufacturer's FAA-approved Airplane Flight Manual (AFM) indicated that the engine's power lever should not be moved below the idle stop position during flight. Movement of the power lever below that range placed the propeller in Beta⁴ mode. Continued rearward movement of the power lever would operate the propeller at a reverse blade angle, and produce 'reverse thrust'.

In-flight operation of the propeller in the Beta mode was not approved by the aircraft manufacturer. In addition, the manufacturer cautioned that operation of the propeller at fine blade angles could disrupt the airflow over the elevator and rudder control surfaces, and potentially contribute to a loss of aircraft control. Moreover, operation in Beta mode significantly increased the propeller drag on the aircraft.

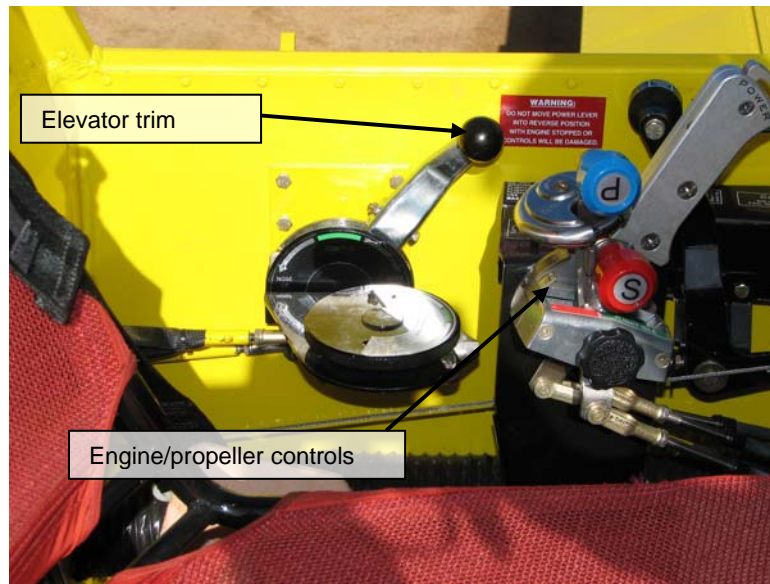
Flight controls and wing flaps

System description

The AT-602 was equipped with conventional flight controls. The ailerons were equipped with aerodynamic boost tabs that assisted the deflection of the control surfaces and reduced aileron control loads. The elevator was equipped with a conventional trim system that was controlled by a trim lever mounted behind the engine controls on the left side of the cockpit (Figure 2). The rudder was equipped with a conventional trim system.

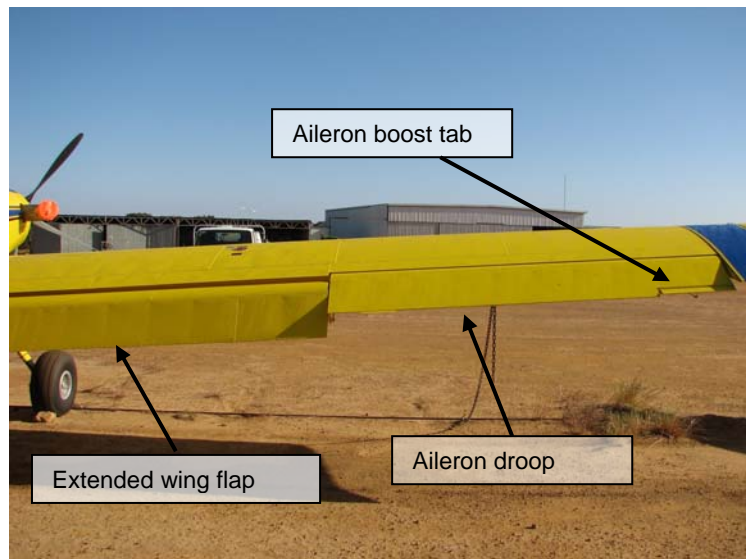
¹² Rated to produce 1,050 SHP at takeoff.

Figure 2: AT-602 engine/propeller controls and elevator trim lever



In addition, the AT-602 was equipped with an electrically-operated Fowler flap system. That system incorporated an aileron interconnection, which symmetrically drooped the ailerons as the flaps extended.¹³ The motion of the aileron interconnection was non-linear, in that most of the aileron droop occurred during the first 15 degrees of flap extension. Full flap extension was 30 degrees, with an associated aileron droop of 10 degrees. Figure 3 illustrates the flap extension and aileron droop.

Figure 3: AT-602, showing extended wing flap and aileron droop



¹³ The droop of the ailerons increased the maximum lift coefficient of the wing, further reducing the stall speed with flap extended and increasing the drag affecting the aircraft.

The flaps were actuated by a finger-operated ‘rocker’-type switch¹⁴ on the control stick (Figure 4). That switch enabled the pilot to extend the flaps between 0 and 30 degrees. The flaps could also be activated by a control switch mounted adjacent to the engine and propeller control levers on the left side of the cockpit (Figure 5).

Figure 4: Control stick for a similarly-equipped AT-602, showing the finger-operated flap ‘rocker’ switch

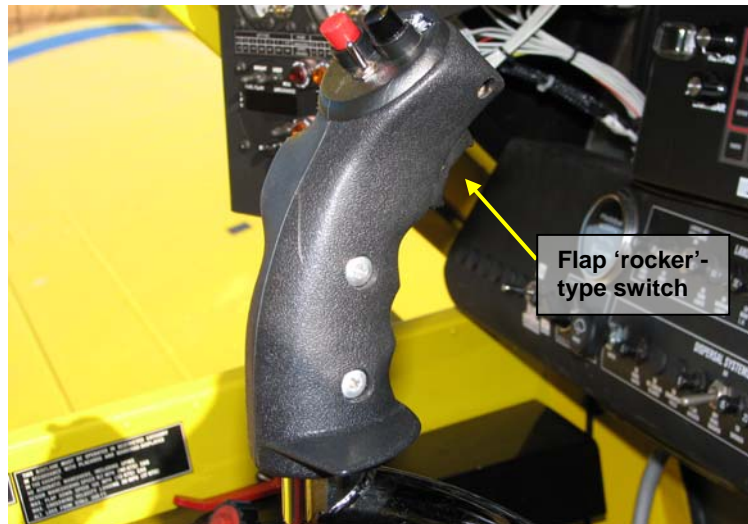


Figure 5: Flap control switch adjacent to the engine controls



¹⁴ That switch was installed following the aircraft’s initial importation to Australia, in accordance with Engineering Order ADG-AT602-EO2125.

Examination of a similarly-equipped AT-602

The investigation requested the operator to time the rate of flap travel during flight in a similarly-equipped AT-602. In that examination, the flaps extended to 10 degrees in approximately 2 seconds and further extension from 10 to 30 degrees took about 5 seconds.

In addition, the ergonomics of the similarly-equipped aircraft's control stick made it possible for a pilot to inadvertently operate the flaps with one of the forefingers applying unintentional pressure to part of the flap switch. Such activation appeared to be more likely when the control column was being gripped tightly or being pulled hard back.

A number of pilots who had used that type of finger-operated flap switch recalled inadvertently operating their aircraft's flaps. However, they reported that the pitch attitude of the aircraft changed as the flaps extended and, consequently, the inadvertent operation of the flaps was immediately apparent. They also commented that having the flap switch on the control stick was an important consideration for agricultural flying, where intermediate stages of flap are frequently required, and where it was important to be able to operate the flaps without removing their hand from any of the engine controls, the trim controls or the drop lever.

Comparison with the Dromader M-18 and pilot's AT-401

The Dromader and AT-401 aircraft did not have finger-operated flap switches on their control sticks.

Water-dropping operations

The aircraft was configured for water-dropping operations and had a 630 US Gallon (2,385 L) capacity fibreglass hopper. A manually-controlled fire-bomber dump door was fitted to the base of the hopper. Activation of the cockpit drop handle by the pilot opened the dump door and allowed the hopper contents to drop from the aircraft.

The AFM recommended that, during water-dropping operations, pilots should use 10 degrees of flap, and an airspeed of 109 kts on approach and load release. The AFM indicated that 'during the load release there will be a sudden pitch-up of the nose of the aircraft' and that 'Approximately 18 pounds of forward pressure will be required to offset the pitch-up tendency'. Those effects were principally as a result of:

- the rearward movement of the aircraft's centre of gravity (CG) as the hopper emptied
- a reduction in the weight of the aircraft, producing a sudden change in the relative airflow and lift on its wing and tailplane
- a change in the airflow around the underside of the aircraft during load release.

The chief pilot reported that, when necessary, engine power was used to maintain the required flight profile and target speed when approaching the drop. For a given approach profile, and when lightly loaded, less power was required than when carrying a full fire-fighting load. The chief pilot stated that a flat approach to the

water drop was normally not preferred, because the pilot lost sight of the drop target under the nose of the aircraft.

Loading

Estimated aircraft operating weight	3,537 kg
Maximum take-off weight	5,670 kg
Estimated CG position	742.7 mm aft of datum
Manufacturer's permitted CG range (at 3,537 kg)	445 mm – 746.2 mm

The investigation estimated that the aircraft's operating weight at the time of the accident was about 3,537 kg, and that the CG was within the range stipulated by the aircraft manufacturer.

Aerodynamic stall speed

The AFM indicated a wings-level aerodynamic stall speed at an operating weight of 4,173 kg of 76 kts calibrated airspeed (CAS)¹⁵ (flaps up), and 61 kts CAS (flaps down). The published maximum altitude loss during the recovery from a wings-level stall in the aircraft was 300 ft. The AFM did not provide information about stall speeds at lower operating weights.

The investigation estimated that, at an operating weight of 3,500 kg, the wings-level aerodynamic stall speed would be about 70 kts CAS (flaps up), and 56 kts CAS (flaps down).

The aircraft was equipped with an audible stall warning horn, which activated approximately 5 kts above the aerodynamic stall speed. Impact damage to the leading edge of the left wing precluded functional testing of the wing-mounted stall warning actuator.

Conventional stall recovery techniques required the application of maximum engine power, the lowering of the aircraft's nose to reduce the angle of attack of the wings, and the use of rudder to prevent any tendency of the aircraft to drop a wing.

Fuel

The aircraft's engine was certified for operation using aviation turbine fuel that met the relevant standards as specified in the aircraft's type certificate. The engine manufacturer's Service Bulletin 13244R7 stipulated the conditions affecting the use of alternate fuels in the PT6A-60AG engine. Those alternate fuels included automotive specification diesel fuel.

Fuel samples were recovered from the airframe fuel filter and from one of the ruptured fuel tanks. A separate fuel sample was obtained from the refuelling equipment at the aerodrome.

¹⁵ CAS is the indicated airspeed corrected for instrument and position errors. At the published aerodynamic stall speeds, the AFM indicated that the calibrated airspeed was within about 1 kt of the indicated airspeed.

All of the fuel samples were tested at a National Association of Testing Authority-approved laboratory. The results of those tests showed that:

- in regard to the fuel samples that were recovered from the aircraft wreckage:
 - neither of the fuel samples complied with the fuel specification for Jet A-1 turbine fuel
 - both of the samples were consistent with a diesel fuel profile
 - excessive foreign matter was visible in the sample obtained from the airframe fuel filter, which was assessed by the testing laboratory as being consistent with bacterial growth in the fuel
- the sample from the aerodrome refuelling equipment was bright in appearance, with some particulate matter present.

The chief pilot confirmed that the aircraft was being operated on diesel fuel, and that a delivery of diesel fuel had recently been received from the bulk fuel supplier. That delivery was not accompanied by a release note to certify that the fuel met prescribed standards, nor had the operator commissioned testing of the fuel to ensure that it complied with the requirements of Service Bulletin 13244R7.

The aircraft was equipped with a cockpit instrument that monitored the quantity of fuel consumed by the aircraft's engine. Examination of that instrument's non-volatile memory showed that, at the time of the accident, the aircraft had consumed a total of 227 L, and that 772 L of fuel remained in the aircraft.

Meteorological information

Witnesses at Ballidu recalled that the weather conditions at around the time of the accident were generally fine, with light south-westerly winds.

The Bureau of Meteorology (BoM) reviewed the available weather data for the afternoon of the accident. That review indicated the presence of south-westerly surface winds and little or no cloud in the Ballidu area at the time of the accident.

The closest official meteorological recording station was at Dalwallinu, about 74 km to the north-west. At the time of the accident, Dalwallinu recorded a south-westerly wind at 8 to 10 kts, and a temperature of about 23° C. The BoM assessed that similar weather would have been experienced at Ballidu.

Communications

The pilot was in communication with the chief pilot who was using a hand-held VHF radio. The chief pilot reported that he did not hear any distress call transmitted by the pilot of the accident aircraft.

Radio transmissions made by aircraft on the aerodrome CTAF¹⁶ were not recorded.

¹⁶ Common Traffic Advisory Frequency.

Wreckage information

Overview of wreckage

The aircraft's final flight path was towards slightly rising terrain. A power line, supported by power poles about 10 m high, ran in an east to west direction along the road adjacent the southern boundary of the aerodrome.

The accident site was located on generally flat, scrub-type terrain. Bushes and small trees, approximately 3 to 5 m high, covered the immediate area. Damage to the vegetation in the vicinity of the initial point of impact with the terrain indicated a steep final flight path towards the ground. The main wreckage came to rest about 23 m south of that impact point (Figure 6).

There was no evidence of a bird strike or collision with other obstacles prior to the impact with the terrain. The aircraft was intact prior to that time.

Figure 6: Terrain impact point and aircraft wreckage



Wreckage examination

Examination of the wreckage and an analysis of the impact loads through the structure of the aircraft indicated a slightly right wing-low, almost nose-level (zero) pitch attitude on impact. The characteristics of the impact were consistent with a high rate of vertical descent and low forward speed.

All of the aircraft's structural components and flight controls were accounted for at the accident site. Examination of the control pushrods for the elevator revealed a fracture at one of the eye-end bearing fittings. Laboratory examination of that component did not reveal any evidence of a pre-existing material anomaly. The fracture surface exhibited characteristics consistent with gross structural overload and failure of that component during the accident sequence.

Damage to the engine's power lever was consistent with the pilot's hand being on that control at impact.

The engine core was substantially intact, but had separated from the propeller reduction gearbox due to impact forces. The propeller was severely damaged by

impact forces and two of the blades had broken away from the hub of the propeller. The engine, propeller and propeller reduction gearbox were recovered for technical examination.

A number of cockpit instruments and indicator globes from the aircraft's annunciator warning panel were recovered from the accident site for technical examination. Those cockpit instruments included: the airspeed indicator; the engine gas generator speed (Ng) indicator, oil temperature and pressure gauges, and torque gauge; and the propeller RPM gauge.

The main landing gear collapsed on contact with the terrain and the fuel tanks ruptured during the impact sequence. There was evidence that a significant quantity of fuel had spilled from each of the tanks. There was no fire.

Damage to the wing flaps was consistent with their being extended at the time of impact.

The jackscrew for the flap actuator separated from the aircraft during the impact sequence and was found along the wreckage trail. The jackscrew remained attached to the actuator gearbox, but had fractured in the vicinity of the ACME-threaded nut assembly that connected the jackscrew to the flap actuator arm. Technical examination of those components revealed a bending overload failure as a consequence of impact forces. The as-found extension measurement of the jackscrew was consistent with the wing flaps being fully extended at the time of the impact with terrain.

Impact forces sheared off the left elevator and left horizontal stabiliser. The right elevator trim tab disconnected from the elevator control surface due to impact forces. Disruption to the elevator and the left and right trim tabs precluded any reliable assessment of the position of the elevator trim at impact.

The aircraft's emergency locator transmitter (ELT) separated from its mounting bracket during the impact sequence. Although the ELT was armed, it did not automatically activate. The ELT was recovered for technical analysis.

Examination of components recovered from the wreckage

Cockpit instruments

Laboratory examination of the instrument face of the airspeed indicator showed witness marks from the indicator needle. Those marks indicated that, at the time the indicator needle contacted the face of the instrument, the needle was indicating between 45 and 55 knots (Figure 7).

Figure 7: Witness mark on face of airspeed indicator



No witness marks were evident on the remaining cockpit instruments that were recovered from the accident site.

Indicator globes from the aircraft's annunciator warning panel

The following indicator globes from the aircraft's annunciator warning panel were examined:

- propeller Beta, which illuminates to indicate when the propeller blade angle is in the Beta⁴ range
- fuel filter, which illuminates when the airframe fuel filter is partially blocked
- low fuel quantity, which illuminates in a low fuel condition
- air filter which, when illuminated, indicates restricted airflow to the engine air inlet
- chip detector, which indicates that metal particles are in contact with the detector terminals and, potentially, in the engine lubricating oil.

There was no evidence in any of those globes of any filament stretch that would normally be associated with their illumination at the time of the impact with terrain.

Global positioning system

The aircraft was equipped with global positioning system (GPS) equipment that had the capability to record the aircraft's position. However, that system was not switched on at the time of the accident.

Engine

The engine core and propeller reduction gearbox were dispatched to the engine manufacturer for disassembly and examination under the direct supervision of the Transportation Safety Board of Canada.

The results of that examination included that impact forces had deformed the engine exhausts and gas generator case. Disassembly of the engine revealed the ingestion of dirt through the engine compressor and turbine sections.

Rotational damage was evident throughout the engine's turbine section, including the turbine disc faces, vane baffles, shroud faces and turbine blade tips. That damage was consistent with the engine producing power at the time of impact. Due to the nature of the impact forces, and the direction in which those forces were resolved through the engine, it was not possible to correlate the observed damage with an approximate power setting at impact.

Inspection of the inner combustion liners revealed typical flame patterns and the fuel nozzles tested normally. Examination of the combustion liners, fuel nozzles and turbine section provided no evidence that the diesel fuel used by the operator had adversely affected the operation of the engine.

Testing of the engine's fuel control unit (FCU) by the manufacturer revealed an anomaly with the set-up of the unit's low and high idle settings, and the maximum power stop. Those adjustments affected the start and acceleration tests performed on the FCU and resulted in a lower than expected full power fuel flow. An analysis of those test results by the manufacturer indicated that:

- the testing schedule was not indicative of the FCU's performance during normal engine operation
- the anomalies identified during testing of the FCU were not significant for the:
 - operation of the engine during the accident flight
 - ability of the engine to produce maximum power.

Testing of the FCU with the power lever set to maximum power confirmed that the FCU was capable of delivering the required fuel flow for maximum power operation.

Propeller

When reconstructed as a set, each of the propeller blades showed a progressive and marked increase in axial twist and rearward, out-of-plane bending around the sequence of rotation (Figure 8). That damage was consistent with a steep angle of impact with terrain (ie low horizontal speed, high vertical speed) and a rapid cessation of propeller rotation.

Figure 8: Propeller blade bending, reconstructed as a set



The pitch change mechanism for the propeller blades was damaged as a consequence of the accident, and each of the blades showed evidence of moving independently during the impact sequence. Marks on the hub of the propeller blades indicated blade rotation beyond the assembly limit of -11 degrees.

There was no evidence to indicate that the propeller was operating in the Beta or reverse blade angle range at the time of impact.

Emergency locator transmitter

The separation of the ELT from the mounting bracket was assessed a consequence of the impact forces, acting predominantly in a vertical plane.

The ELT was tested after the accident and activated normally.

Medical and pathological information

Medical and survival aspects

Post-mortem examination indicated that, during the impact sequence, the pilot sustained severe neck and head injuries. The severity of those injuries made the accident non-survivable.

The pilot was not wearing a protective helmet during the flight.¹⁷ The investigation obtained a specialist medical opinion regarding the severity of the pilot's injuries and an assessment of the survivability of the accident had the pilot been wearing a protective helmet. That assessment concluded that, given the significant vertical impact forces, it was unlikely that the use by the pilot of a protective helmet would have reduced the severity of the injuries to the pilot's head and neck.

The pilot was using a four-point safety harness.

Toxicology

Toxicology testing revealed the presence of cannabis metabolites in the pilot's blood and urine. That included:

- the active metabolite, tetrahydrocannabinol (THC), at a concentration of 1.5 µg/litre, and
- the inactive metabolite, carboxytetrahydrocannabinol (THC-COOH), at a concentration of 24 µg/litre.

In the context of this accident, specialist medical opinion was obtained regarding the significance of the toxicology results. That advice included that the presence of THC was consistent with the ingestion of cannabis by the pilot in the 24-hour period prior to the accident. On the basis of that evidence, the specialist commented that:

...the adverse effects on pilot performance of recent cannabis use must be considered a significant factor in the fatal accident involving VH-NIT.

In March 2004, the Australian Transport Safety Bureau (ATSB) released a research report titled '*Cannabis and its Effects on Pilot Performance and Flight Safety: A Review*' (available at www.atsb.gov.au). That report reviewed the scientific research on the use of cannabis and examined the manner in which the use of cannabis could affect the ability of a pilot to operate an aircraft.

The pharmacological effects of cannabis use include effects on cognitive and psychomotor function that can significantly impair the ability to perform complex tasks that require attention and mental coordination. Complex tasks requiring rapid responses and discriminations, such as the management of in-flight emergencies, are especially sensitive to cannabis impairment.

In general, acute cannabis use contributes to a deterioration in flying skill, with an increase in the number of errors made by a pilot. Of particular significance, a cannabis-affected pilot is typically unaware of the extent to which their performance has been impaired. Moreover, as indicated in the ATSB research report, significant performance impairment as a carry-over effect of cannabis use has been demonstrated in pilots at up to 24 hours following exposure.

¹⁷ The AFM stipulated the use of a protective helmet when operating the aircraft.

Additional information

Operator information

The operator held a CASA-issued Air Operator's Certificate, which authorised the conduct of water-dropping operations in the AT-602 as an aerial work activity. The operator was contracted to provide fixed-wing agricultural aircraft for fire-fighting operations during the summer bushfire season.

The chief pilot was supervising the pilot during the day of the accident and had previously been issued a CASA approval to conduct endorsement training on Thrush/Air Tractor (PT6A) type aircraft.

Turbine-powered aircraft – operating implications

In response to the movement of the power lever, a turbine engine can exhibit a slight acceleration lag, particularly when the engine is accelerated from low RPM. In addition, the relationship of power lever position to engine power output in a turbine engine is non-linear, with most of the engine power being produced in the final part of the power lever movement. The factors with the potential to affect the acceleration of a turbine engine include the engine's design characteristics and the operating speed from which the engine is accelerated.

A number of instructor pilots reported that, when conducting endorsement training for pilots who were unfamiliar with operating turbine engines, those pilots were often conservative with their power applications. That was suggested by the instructor pilots to be as a consequence of the trainees being unfamiliar with the response of a turbine engine to a given movement of the power lever, and their concern to not exceed a temperature or torque limit on the engine.

The airspeed indicator was highlighted by a number of pilots as being a particularly important instrument in a turbine-engine aircraft like the AT-602. They reported that the cockpit environment can be deceptively quiet and that the cues and sensations that might normally be associated with a reducing airspeed are less salient than when compared with a piston-engine aircraft.

Dromader dropping technique

During the investigation, the chief pilot reported that he had recently become aware of a dropping technique used by some of his Dromader pilots. That technique was reported to help control the aircraft following load release and involved the application of full-forward trim immediately prior to the load release. In addition, the use of full flap, and a low (typically idle) power setting, was reported to improve the visibility of the drop target to the pilot.

The chief pilot indicated that one of his experienced pilots had tested this scenario in the operator's other AT-602. The experienced pilot reported that, in the dropping configuration, the aircraft remained controllable with full-forward trim. However, when power was applied, the forward load on the control stick increased rapidly and the nose of the aircraft pitched suddenly and violently downwards. As the nose pitched down, the airspeed rapidly increased and the stick control loads increased further.

Review of drop logs

During the first part of the fire season following the accident, the operator provided the investigation with GPS drop logs from the operator's AT-602 and AT-802 aircraft. Those logs recorded information on fire-fighting aircrafts' altitude, groundspeed and position during water-dropping operations.

An analysis of 27 drop logs from the operator's other, similarly-equipped, AT-602 aircraft typically indicated a reduction in the recorded groundspeed during water drop manoeuvres and an increase in aircraft altitude. A number of factors were identified with the potential to have influenced the recorded data, including the:

- profile of the manoeuvre flown, which varied depending on the terrain in the vicinity of the drop site
- potential requirement for a steep climb in order to avoid terrain
- effect of windshear and wind gradients when operating close to the ground.

The groundspeed reductions during the recorded drop manoeuvres ranged from between 3 to 28 kts, with the majority of groundspeed reductions being less than 10 kts. The average reduction in groundspeed was about 8 kts.

Testing of safety-sensitive personnel for alcohol and other drugs

In March 2004, the ATSB issued Safety Recommendation R20040039 in regard to the potential safety benefits of the establishment of a drug and alcohol testing program for safety-sensitive personnel. That recommendation stated:

The Australian Transport Safety Bureau recommends that the Civil Aviation Safety Authority, in conjunction with the Department of Transport and Regional Services, establish the safety benefits of the introduction of a drug and alcohol testing program to the Australian aviation industry for safety-sensitive personnel. Where possible, this program should harmonise with existing and evolving national and international regulations.

Concurrent with the release of that recommendation, the then Deputy Prime Minister and Minister for Transport and Regional Services also announced a review of the safety benefits of the introduction of a drug and alcohol testing program for safety-sensitive personnel in the Australian aviation industry.

The Department of Transport and Regional Services (DOTARS) released its report¹⁸ in January 2006. That report concluded that a testing regime was justified from a safety perspective, and provided a framework for how such a regime might be implemented. The recommendations included a broad approach to testing in various forms, supported by educational initiatives to warn of the dangers posed by drug and alcohol use.

The Minister for Transport and Regional Services subsequently directed CASA to commence work on implementing the report's recommendations. As a result of that work, on 8 May 2007, the Deputy Prime Minister and Minister for Transport and Regional Services announced the introduction of mandatory drug and alcohol testing in the Australian aviation industry. Those tests are planned to commence in 2008.

18 See <http://www.dotars.gov.au/aviation/safety/drug.aspx>.

ANALYSIS

The circumstances of the accident were consistent with a sudden loss of aircraft control, at a height that was insufficient for the pilot to recover the aircraft to normal flight before impacting the terrain.

Consideration of the loss of control

The witness reports and their description of the aircraft's approach towards the aerodrome were consistent with the pilot positioning the aircraft for the purpose of making a practice water drop.

No anomaly was identified with the aircraft or its systems that would have affected its normal operation during the flight. Despite the foreign material visible in the fuel sample that was obtained from the airframe fuel filter, there was no evidence that the use of diesel fuel, or its quality was a factor in the occurrence.

The witness marks on the face of the airspeed indicator were most probably as a result of the peak forces experienced by the aircraft early during the impact sequence. The upper range of those witness marks (55 kts) approximated the investigation-calculated, flap down aerodynamic stalling speed of about 56 kts. That, and the pattern of damage to the aircraft were consistent with the loss of aircraft control being the consequence of an aerodynamic stall.

Potential influence of the turbine-engine and its management

The proximity of the water drop site to the point of impact with the terrain indicated that the loss of control occurred soon after completion of the drop, and during the period where it could be expected that the pilot was increasing engine power. The pilot's relative unfamiliarity with the turbine-engine AT-602 suggested that he probably would have been closely monitoring the engine instruments, and that he may have been conservative with any power application as he adjusted to the turbine engine's acceleration response characteristics. Any tendency by the pilot to focus on the engine's operation would have reduced his ability to monitor other parameters of aircraft performance, such as the aircraft's airspeed and its associated cues and sensations.

In addition, if there was more water in the hopper than was estimated by the chief pilot, then the pilot would have experienced a stronger pitch-up moment during the load release. That would have exacerbated any loss of airspeed. However, the increased weight of the aircraft may have necessitated a higher power setting on approach to the target area and during the drop. Had that been the case, the engine's acceleration to climb power could have been expected to have been more rapid.

Alternately, if the aircraft was lightly loaded, then a lower power setting would probably have been required during the approach to the target area. In that case, the time for the aircraft's turbine engine to accelerate to the higher power settings necessary for the post-drop climb out would have increased.

The use by the pilot of the same hand to operate the dump door and to adjust the engine power and trim settings meant that it was unlikely the pilot had the opportunity to adjust the engine's power setting during the water drop. More probably, he would have returned his hand to the power lever immediately following the drop in order to adjust the engine power to that required for the post-drop climb out.

Consideration of the use of wing flaps by the pilot

It was unlikely the pilot would have intentionally made a practice water drop with full flap extended. Rather, the pilot would most likely have approached the drop zone with the wing flaps set to 10 degrees as recommended by the aircraft manufacturer. Given the manufacturer's recommended approach speed and flap setting, it was unlikely that the pilot would have reduced the engine power lever to below the idle stop approaching the drop zone, thereby placing the propeller in Beta mode.

It was not possible to establish whether full wing flap was extended either prior to, during or immediately following the water drop. However, because of the aircraft's low height above the ground, and the sudden departure from controlled flight and impact with terrain, it was unlikely there was sufficient time for the flaps to extend from 10 to 30 degrees after the departure from controlled flight.

Although extending wing flap has the benefit of reducing the aerodynamic stall speed, it also significantly increases the drag affecting an aircraft. If the wing flaps had fully extended prior to the loss of control, the associated additional drag would have exacerbated any loss in airspeed following the drop, particularly if the engine was operating at a reduced power setting.

Extending full wing flap was not a conventional stall recovery technique and would have reduced the aircraft's acceleration to a safe flying speed. Consequently, the investigation considered that it was unlikely that the pilot intentionally selected full flap as part of an attempt to recover the aircraft's airspeed.

The nature of the drop manoeuvre and the resultant pitching of the aircraft nose during the load release would have made it more difficult for the pilot to detect any inadvertent operation of the flaps during, or immediately following the water drop.

Toxicology results

The pilot's recent use of cannabis, and particularly the presence of the active cannabis metabolite, tetrahydrocannabinol (THC), at a concentration of 1.5 µg/litre may have adversely impacted on his ability to operate the aircraft. That included on his ability to respond quickly to critical in-flight events and to recognise deteriorating or unfamiliar situations. Moreover, any requirement for the pilot to apply emergency procedures, or to detect significant airspeed excursions that required the discrimination of a changing condition, such as the inadvertent operation of the aircraft's wing flaps or an unanticipated reduction in airspeed, would have been adversely affected.

FINDINGS

Contributing safety factors

- The pilot lost control of the aircraft at a height from which there was insufficient time to recover the aircraft to normal flight.
- The loss of aircraft control was most probably the result of an aerodynamic stall.

Other safety factors

- The pilot's recent ingestion of cannabis may have adversely affected his ability to operate the aircraft.
- The aircraft's low altitude during the water drop significantly restricted the available recovery options in the event of unexpected or unanticipated aircraft behaviour.
- The pilot had minimal water-dropping experience in the turbine-engine-powered AT-602 aircraft.

Other key findings

- The aircraft was capable of normal operation at the time of the accident.
- There was no evidence that the use of diesel fuel in the aircraft, or its quality were factors in the occurrence.

SAFETY ACTION

The operator has commenced a program to install additional monitoring and warning equipment in his aircraft.

That equipment performs a trend monitoring function for various engine and airframe parameters. It also captures data when monitored parameters are exceeded, and provides a visual/audio alert to the pilot.