Australian Government
Australian Transport Safety Bureau

Australian Transport Safety Bureau
PO Box 967, Civic Square ACT 2608
Australia

1800 020 616

+61 2 6257 4150 from overseas

www.atsb.gov.au

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ATSB TRANSPORT SAFETY REPORT
Aviation Occurrence Investigation AO-2009-060
Final

Collision with terrain, VH-ODP 5 km north-east of Wickepin, Western Australia 3 October 2009

Abstract

At 1153 Western Standard Time on 3 October 2009, the pilot of an Air Tractor Inc. 502 aircraft, registered VH-ODP, took off from an agricultural airstrip on a property about 5 km north-east of Wickepin, Western Australia to conduct agricultural spraying operations. A short time later, the owner of the property discovered the wreckage of the aircraft, which had impacted the ground in an inverted attitude, fatally injuring the pilot.

There were no witnesses to the accident; however, the investigation determined that the aircraft had made contact with the upper branches of a tall tree prior to impact with the terrain.

The investigation did not identify any organisational or systemic issues that might adversely affect the future safety of aviation operations.

FACTUAL INFORMATION

History of the flight

At about 1153 Western Standard Time[1] on 3 October 2009, the pilot of an Air Tractor Inc. 502 (AT-502) aircraft, registered VH-ODP (ODP), took off from an agricultural airstrip to commence agricultural spraying operations on a canola crop about 5 km north-east of Wickepin, Western Australia.

The pilot had repositioned the aircraft that morning from an airstrip that was located about 180 km north of Wickepin, arriving at the property airstrip at 1100. The property owner briefed the pilot on the area to be sprayed and the aircraft's hopper was loaded with pesticide before taking off on the first application flight. The loader[2], who was employed by the pilot of ODP, recalled that the aircraft seemed to take longer than normal to become airborne for the flight. However, he also recalled that the load of spray was several hundred litres more than had been carried on recent flights by the pilot.

At about the time the loader was expecting the aircraft to return for a second load of spray, the owner of the property discovered the wreckage of the aircraft in a paddock, adjacent to the crop being sprayed and 2 km from the property airstrip. The aircraft had impacted the ground, in an inverted attitude, about 150 m north of a large tree (Figure 1). The tree's canopy showed signs of impact from the aircraft. There were no witnesses to the accident.

The pilot sustained fatal injuries and the aircraft was seriously damaged[3].

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 Term used to denote ground support personnel whose functions include assisting with mixing chemicals and loading and dispatching the aircraft.

3 The *Transport Safety Regulations 2003* define 'serious damage' as including the 'destruction of the transport vehicle'.

Figure 1: Main wreckage (looking approximately south)

Pilot information

The pilot held a valid Commercial Pilot (Aeroplane) Licence that was issued in June 1998, and was subsequently endorsed with a Grade 2 Agricultural Rating in July 1998 and a Grade 1 Agricultural Rating in May 2001. The majority of the pilot's total aeronautical experience of 4,730 hours was in aerial agricultural operations on piston-engine aircraft, including the Cessna 188 and the Fletcher FU-24. The pilot successfully completed an annual proficiency check in accordance with *Civil Aviation Safety Regulations (CASR) Part 137.240* on 19 May 2009.[4]

In July 2009 the pilot, who operated his own aerial agriculture business, was given the opportunity to fly an AT-502 (ODP) that was owned by another operator. That aircraft type was powered by a turboprop engine and, as all of the pilot's flying experience had been accumulated on piston-engine aircraft, the pilot undertook training for a separate endorsement. That training was conducted by an experienced AT-502 pilot, who held a training approval from the Civil Aviation Safety Authority (CASA), and was completed on 31 July 2009. Although there was no regulatory requirement, it was arranged for another experienced AT-502 pilot to monitor the pilot for several days following his endorsement training.

Over the following 2 months, the pilot accumulated about 100 hours of flight experience in ODP. Some of that time involved aerial top-dressing, which was usually carried out above treetop height, and the remainder in ferry flights. It was estimated that, at the time of the accident, the pilot's spraying experience in the AT-502 amounted to less than 75 hours.

The pilot held a current CASA-issued Class 1 Medical Certificate without restriction that was valid to 7 April 2010. On the day before the accident, the pilot flew about 3 hours on aerial spraying operations. Prior to that, the pilot had not flown since 26 September 2009.

The pilot was reported to be well rested and in good health on the day of the accident. Colleagues described the pilot as being level-headed and conservative with his operation of aircraft.

Aircraft information

The aircraft was a single-seat agricultural aircraft that was manufactured in 1989 in the United States (US) by Air Tractor Inc. It was powered by a Pratt & Whitney PT6A-15AG turboprop engine that was rated at 680 shaft horse power and drove a Hartzell three-blade, constant-speed, reversible-pitch propeller.

The aircraft was maintained by an organisation holding a CASA-issued Certificate of Approval to conduct aircraft maintenance. A scheduled 100-hourly maintenance inspection was carried out on 22 June 2009 and a maintenance release was issued that was valid to 9,323.9 hours total time in service (TTIS) or until 22 June 2010, whichever came first.

Since the pilot's AT-502 endorsement on 31 July 2009, the daily inspection certification and the aircraft time-in-service section of the maintenance release had not been completed as required by the Civil Aviation Regulations[5]. An exact record of flight time was therefore not available to the investigation; however, other documentation indicated that, at the time of the accident, the aircraft had about 9,338 hours TTIS.

The US Federal Aviation Administration (FAA)-approved Airplane Flight Manual (AFM)

4 CASR Part 137.240 stated that the pilot in command of an aeroplane could not commence an application operation, unless, on the day of the operation, the pilot held a valid annual proficiency check.

5 *CAR 43B* required that, on completion of each day's flying operations, the owner, operator or pilot in command must record on the aircraft's maintenance release the total time-in-service of the aircraft on that day.

specified a maximum agricultural gross take-off weight of 3,296 kg. However, the AT-502, like most agricultural aircraft, had provision in its Type Certificate Data Sheet (TCDS)[6], for a higher maximum gross take-off weight under prescribed conditions of altitude, outside air temperature and airspeed.

The TCDS applicable to ODP stated that, under those conditions, the aircraft type and model had demonstrated satisfactory operation at a maximum gross take-off weight of 3,855 kg. That maximum weight was specified in the AFM and operation at that increased weight was permitted by CASA under *Certificate of Exemption CASA EX30/09*.

In reference to operation at gross weights in excess of the agricultural maximum gross take-off weight, the AFM stated that, in part:

> Operation of the aircraft at gross weights in excess of the agricultural gross weight for take-off will be at the discretion and on the responsibility of the pilot.

and that:

> ...the handling and stability qualities have not been examined at weights beyond the agricultural gross weight for take-off and the pilot should therefore exercise caution in handling the aeroplane.

The loader recalled that the pilot asked for 1,600 L of water-based chemical pesticide to be loaded into the hopper prior to commencing spraying operations. However, the loader stated that slightly less than that amount was actually loaded. The loader also said that the aircraft had not been refuelled after its positioning flight but that the fuel tanks, which were capable of holding 796 L of fuel, had been filled to capacity the previous evening. It was estimated that, at the time of the accident, the aircraft's operating weight was close to its maximum gross take-off weight of 3,855 kg.

Meteorological information

Persons in the vicinity of the accident site described the weather conditions as being fine, with a light south-westerly wind, good visibility and a temperature of about 18 °C. That was consistent with the pilot's observations of the weather as recorded on his job sheet prior to commencing the spraying operations.

The Bureau of Meteorology reviewed the available weather data for the time of the accident and summarised the conditions as being dry, with a scattered cloud base of about 3,000 ft above ground level and a south-westerly wind at 10 to 15 kts.

Recorded information

The aircraft was fitted with a Satloc satellite navigation system that provided tracking guidance to the pilot to facilitate accurate spray coverage of the crop. The system recorded in-flight data to a memory card that included the time and the aircraft's position, speed, track and altitude. Components from that system were recovered from the accident site for technical examination.

The memory card from the Satloc was found to contain data for the first 4 minutes of the flight but did not retain the data for the spray run prior to the accident. According to the equipment manufacturer, data was temporarily stored in the operating system (buffer) of the Satloc unit, before being transferred to the memory card every 30, 45 or 60 seconds, depending on the software. Any data not transferred to the memory card was lost when power was removed from the system.

Recorded information from the memory card showed that the aircraft became airborne on a southerly heading and continued in that direction flying parallel and close to a farm track that separated two adjacent fields of canola that the pilot intended spraying. The fields were approximately rectangular in shape and the boundaries were aligned north-south/east-west. The recorded data is depicted in Appendix A.

The pilot carried out the first spray run on a southerly heading, along the eastern boundary of the first field. That run was followed by a right turn, consistent with the pilot positioning the aircraft to spray the western boundary of that field. The last recorded data from the Satloc was midway during that turn, at 1157:06.

6 TCDS. In this case, issued by the US Federal Aviation Administration and describing an aircraft, its engine or its propeller. A TCDS lists the limitations and information required for type certification including an aircraft's airspeed and weight limits, thrust limitations, and so on.

Spraying considerations

The field that was being sprayed was bordered by a row of trees on its western boundary. Due to the westerly component of the prevailing wind, to effectively treat that boundary, the pilot needed to fly low and above that line of trees in order for the spray to drift with the wind and onto the crop. Dead pests on the crop along the western boundary confirmed that section of crop had been effectively treated with pesticide.

The direction of the prevailing wind would also have given the aircraft a slight tailwind component. The investigation calculated that, prior to the accident, the aircraft was being operated at a groundspeed of about 200 km/h, on a spray run that was estimated to take 9 seconds.

Because of the variation in the elevation of the terrain, the aircraft's flightpath during that spray run would have commenced at a height about level with the top of the tree that was struck (refer to Figure 1). To maintain the required constant height in relation to the crop, the pilot would have had to gradually descend the aircraft as the spray run progressed, before pulling up to avoid the largest of the trees.

Wreckage information

Debris from the aircraft's spray boom, and a substantial number of tree branches of between 50 and 150 mm in diameter, were found at the base of a 23 m high tree that was located at the north-western corner of one of the canola crops that was to be sprayed. That tree was significantly taller than the other trees that ran along the western boundary of the crop (Figure 1).

When examined, none of the fallen branches exhibited signs of cutting that would be expected if they had come into contact with the aircraft's propeller. There was damage to the leading edges of the aircraft's wings, consistent with the damage observed to the tree's canopy. The most extensive tree impact damage was on the right wing (Figure 2), where 50% of the leading edge was disrupted. There was a lesser amount of tree impact damage to the left wing.

The aircraft impacted the ground about 150 m north of the 23 m high tree and about 10° to the right of the direction of the spray run in an inverted, 40° nose-down attitude. The aircraft slid inverted for about 50 m, before coming to rest, with numerous items of aircraft wreckage distributed along the wreckage trail. Damage to the aircraft was consistent with a high-energy impact.

The aircraft's hopper and fuel tanks were ruptured on impact with the ground. A considerable quantity of pesticide and fuel had spilled onto the site from the aircraft's hopper and wing fuel tanks respectively. There was no fire.

The propeller blades and the engine's compressor blades exhibited damage that was consistent with significant power delivery at terrain impact. The aircraft's engine and propeller were removed from the site and examined at a number of CASA-approved overhaul facilities under the supervision of the Australian Transport Safety Bureau (ATSB). No mechanical defects or anomalies were identified.

Examination of the aircraft's flight controls verified their continuity prior to the collision with the ground, and that all control linkage failures observed were as a consequence of ground impact forces. The wing flaps were found in the retracted position.

A small quantity of fuel was recovered from the main inlet hose to the engine-driven fuel pump. A separate fuel sample was obtained from the aircraft operator's bulk fuel storage. Those samples were tested at a National Association of Testing Authorities-approved laboratory and verified as being of identical chemical composition and an approximate 80/20 blend of diesel and aviation kerosene. That blend was described by the aircraft operator as their 'regular' fuel mix. While the engine manufacturer did not recommend running on diesel or diesel blends, a manufacturer's Service Letter stipulated the required conditions in order to operate with that fuel mix. A review of the aircraft's maintenance records indicated that those conditions were satisfied in this case.

The evidence from the accident site and the subsequent component inspections indicated that the aircraft and its systems were capable of normal operation prior to the collision with the tree canopy.

Figure 2: Damage to the leading edge of the aircraft's right wing

Additional information

Effect of increased weight

An increase in take-off weight affects an aircraft's flight performance characteristics in a number of ways, including a higher take-off speed, a longer take-off run, a reduced rate and angle of climb after takeoff and a higher stalling speed. Of significant importance to flight at very low level is that an increase in weight will increase aircraft momentum and may require extra anticipation by the pilot in order to safely clear an obstacle.

Aerodynamic lift

The amount of aerodynamic lift generated by an aircraft's wing is, amongst other factors, dependent on the smooth flow of air over the wing. The type of leading edge damage observed on ODP would not only disrupt the smooth flow of air over that section of the wing, it would also increase drag and reduce the total effective wing area, resulting in a reduction in the lift generated. As a consequence, the uneven lift produced between the left and right wings could induce a rolling motion exceeding the control authority of the aircraft's flight controls at a given airspeed, and result in a loss of aircraft lateral control.

Pilot distraction

Agricultural pilots operate in an environment that can be physically and mentally demanding. They are required to maintain an accurate height and direction close to the ground while manoeuvring around obstacles in a loaded aircraft. Adding to the high workload is the requirement to monitor the aircraft's systems, including the spray and satellite navigation equipment.

The ATSB Research Investigation Report B2004/0324 *Dangerous Distraction: An examination of accidents and incidents involving pilot distraction in Australia between 1997 and 2004*[7] analysed data from incidents and accidents that were attributed to pilot distraction. The report proposed that pilot distractions could be broadly classified into four groups, including:

- Visual distraction – in or outside of the cockpit.
- Auditory distraction – radio or mobile telephone.
- Biomechanical distraction – manipulating a control.
- Cognitive distraction – being engrossed in the task.

Each of those types of distraction, either singularly or in combination, could take a pilot's attention away from the flying task.

The report made the following conclusions:

- Distraction affected all operational groups, including agricultural operations.
- Distractions can arise unexpectedly, during periods of high or low workload, or during any phase of flight.

ANALYSIS

The aircraft's impact with the ground in an inverted, steep nose-down attitude was most likely a result of loss of control due to extensive damage to the aircraft's wings; in particular, to the leading edge of the right wing. That damage produced an asymmetry of lift between the left and right wings, and a consequential roll from which the pilot was unable to recover before colliding with the ground. The nature of the damage to the leading edge of the wings was consistent with damage observed

7 Available at http://www.atsb.gov.au/publications/2005/distraction_report.aspx

to the tree in the north-western corner of the field being sprayed.

Immediately prior to colliding with the tree canopy, the pilot was most probably conducting the spray run above the line of trees of generally uniform height that were bordering the edge of the crop. That was consistent with ensuring that the spray solution was deposited effectively under the prevailing conditions.

However, that flightpath required a pull-up manoeuvre over a larger, 23 m high tree at the end of the spray run. Such a manoeuvre was a routine aspect of spraying operations and would have been a normal task for an agricultural pilot. For reasons that could not be determined, the pull-up was not conducted in a way, or in sufficient time for the aircraft to avoid striking the upper branches of the 23 m tall tree.

The apparent height at which the aircraft passed through the tree's canopy was above the probable height for the optimum delivery of pesticide onto the crop. That was consistent with the pilot having commenced a pull-up manouvre soon before colliding with the tree's canopy.

The pilot had considerable agricultural flying experience, had completed the requisite endorsement training and had been flying the Air Tractor 502 (AT-502) aircraft for 2 months prior to the accident. In contrast to his overall flying experience, the pilot's experience on the heavier, turboprop-powered AT-502 was relativeley limited. Whether that limited experience on the AT-502 was sufficient to give the pilot a full appreciation of the handling characteristics of the aircraft could not be determined.

When compared to the lighter weight aircraft on which the pilot had gained the majority of his flying experience, the momentum of the AT-502 was about twice that of those lighter aircraft. That extra momentum would have required additional time to effect a desired change in the flight path of the aircraft and increased anticipation by the pilot. In addition, the aircraft was operating close to its maximum gross take-off weight when it collided with the tree. The investigation was unable to establish the extent to which that weight impacted on the manouvrability of the aircraft, and the pilot's ability to manoeuvre the aircraft clear of the tree.

There were a number of other factors with the potential to have contributed to an ineffective pull-up manoeuvre by the pilot. The probable flight path flown by the pilot to maximise the effectiveness of the pesticide drift could have contributed to the larger tree being on or below the pilot's visual horizon. Had that been the case, there was the potential for the tree to have blended into the background as the pilot commenced the spray run.

The pilot's attention could have been diverted from the tree as the spray run progressed, either due to workload or another unknown distraction. The spray run preceeding the accident was unusually short, estimated to last only 9 seconds, and was conducted with a slight tailwind component and at a heavy weight. A gradual descent before the pull-up manoeuvre was also required to maximise the effectiveness of the pesticide drift. Consequently, the spray run was a period of relatively high pilot workload.

The short spray run and high pilot workload increased the potential for the pilot's attention to be diverted away from monitoring the aircraft's flightpath and the proximity of the aircraft to significant obstacles. Given that the majority of the pilot's experience was in aircraft that were lighter than the AT-502, it was possible that the pilot may have temporarily lost awareness of his proximity to the tree and not allowed adequate time to climb clear of the tree. That contention is supported by the observation that the aircraft had probably commenced a climb a short time before colliding with the tree's canopy.

The lack of entries in the aircraft's maintenance release since 31 July 2009, and therefore lack of ready visibility for pilots of the aircraft's total time in service (TTIS), may have contributed to the aircraft's TTIS exceeding the limiting TTIS in the maintenance release. Although in this case no mechanical or maintenance anomaly was identified to indicate an airworthiness issue, exceeding stipulated maintenance intervals can erode safety margins.

FINDINGS

Context

From the evidence available, the following findings are made with respect to the collision with terrain that occurred 5 km north-east of

Wickepin, Western Australia on 3 October 2009 and involved Air Tractor Inc. 502 aircraft, registered VH-ODP and should not be read as apportioning blame or liability to any particular organisation or individual.

Contributing safety factors

- For reasons that could not be determined, the aircraft struck the upper branches of a tall tree during a pull-up manoeuvre from a spray run that had most probably been conducted above a line of smaller trees of generally uniform height.
- The damage sustained by the leading edge of the aircraft's right wing during the collision with the canopy of the tree, resulted in the pilot losing lateral control of the aircraft and the aircraft rolling inverted before colliding with the ground.

Other safety factors

- The aircraft's total time in service (TTIS) exceeded the limiting TTIS in the aircraft's maintenance release.

Other key findings

- The pilot had limited experience in large, turboprop-powered agricultural aircraft.
- At the time of the collision with the tree, the aircraft was being operated at a weight that was close to its maximum gross take-off weight.

SOURCES AND SUBMISSIONS

Sources of Information

The sources of information during the investigation included the:

- aircraft operator
- pilot's AT-502 endorsement trainer
- loader
- Civil Aviation Safety Authority (CASA)
- Bureau of Meteorology.

References

Flight at Lower Levels – John Freeman (1995) - Wakefield Press. ISBN 1 86254 366 6.

Submissions

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

A draft of this report was provided to CASA and the aircraft operator.

The submissions from those parties were reviewed and, where considered appropriate, the text of the draft report was amended accordingly.

APPENDIX A: DEPICTION OF RECORDED DATA