Australian Government

Australian Transport Safety Bureau

Collision with terrain – PZL-Mielec M18A Turbine Dromader, VH-FOZ

23 km WSW of Dirranbandi, Queensland | 19 July 2011

Investigation

ATSB Transport Safety Report

Aviation Occurrence Investigation

AO-2011-082

Final

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ATSB TRANSPORT SAFETY REPORT

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Released in accordance with section 25 of the *Transport Safety Investigation Act 2003*

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SAFETY SUMMARY

What happened

At 1157 on 19 July 2011, a PZL-Mielec M18A Turbine Dromader aircraft, registered VH-FOZ, impacted terrain on a cotton station about 23 km west-south-west of Dirranbandi, Queensland while conducting a spraying flight. The pilot was fatally injured and the aircraft was destroyed by impact forces.

What the ATSB found

The ATSB found that, for reasons that could not be determined with certainty, the aircraft departed from controlled flight during a turn at low altitude and the pilot was unable to recover before impacting the ground.

The ATSB also identified a significant safety issue affecting the safety of future spraying operations in turbine Dromader aircraft: the potential for the aircraft's centre of gravity to vary significantly depending on the weight in the aircraft's chemical/spray tank and exceed the forward and aft limits during a flight. This safety issue was unlikely to have contributed to the accident as the aircraft was probably within the approved weight and balance limits at the time of the accident.

Moreover, although also not found to have contributed to the accident, there was an increased risk to the flight from the aircraft's operation, at times, in excess of its published airspeed and angle of bank limitations.

What has been done as a result

During the investigation, the Australian Transport Safety Bureau worked with the Civil Aviation Safety Authority (CASA) and the Aerial Agricultural Association of Australia to address the risk to turbine Dromader aircraft of the potential for excessive movement of the aircraft's centre of gravity as the contents of the aircraft's chemical/spray tank are dumped or dispensed.

CASA and the owner/developer of the approval for operations at weights of up to 6,600 kg, which had effect during the flight, took action to improve operator and pilot understanding of the issue. In addition, the owner/developer indicated that the design would be reviewed to address any excessive centre of gravity variations.

Safety message

Although it was not contributory in this instance, the ATSB highlights the importance of pilots maintaining their aircraft's weight and balance within limits throughout a flight, and of understanding the implications of changing weight and balance. Similarly, the ATSB reaffirms the importance of being familiar with and adhering to aircraft operational limitations.

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THE AUSTRALIAN TRANSPORT SAFETY BUREAU

The Australian Transport Safety Bureau (ATSB) is an independent Commonwealth Government statutory agency. The Bureau is governed by a Commission and is entirely separate from transport regulators, policy makers and service providers. The ATSB's function is to improve safety and public confidence in the aviation, marine and rail modes of transport through excellence in: independent investigation of transport accidents and other safety occurrences; safety data recording, analysis and research; fostering safety awareness, knowledge and action.

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 identify and reduce safety-related risk. ATSB investigations determine and communicate the safety factors related to the transport safety matter being investigated. The terms the ATSB uses to refer to key safety and risk concepts are set out in the next section: Terminology Used in this Report.

It is not a function of the ATSB to apportion blame or determine liability. At the same time, 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 initiate proactive safety action that addresses safety issues. Nevertheless, the ATSB may use its power to make a formal safety recommendation either during or at the end of an investigation, depending on the level of risk associated with a safety issue and the extent of corrective action undertaken by the relevant organisation.

When safety recommendations are issued, they focus on clearly describing the safety issue of concern, rather than providing instructions or opinions on a preferred method of corrective action. As with equivalent overseas organisations, the ATSB has no power to enforce the implementation of its recommendations. It is a matter for the body to which an ATSB recommendation is directed to assess the costs and benefits of any particular means of addressing a safety issue.

When the ATSB issues a safety recommendation to a person, organisation or agency, they must provide a written response within 90 days. That response must indicate whether they accept the recommendation, any reasons for not accepting part or all of the recommendation, and details of any proposed safety action to give effect to the recommendation.

The ATSB can also issue safety advisory notices suggesting that an organisation or an industry sector consider a safety issue and take action where it believes appropriate, or to raise general awareness of important safety information in the industry. There is no requirement for a formal response to an advisory notice, although the ATSB will publish any response it receives.

TERMINOLOGY USED IN THIS REPORT

Occurrence: accident or incident.

Safety factor: an event or condition that increases safety risk. In other words, it is something that, if it occurred in the future, would increase the likelihood of an occurrence, and/or the severity of the adverse consequences associated with an occurrence. Safety factors include the occurrence events (e.g. engine failure, signal passed at danger, grounding), individual actions (e.g. errors and violations), local conditions, current risk controls and organisational influences.

Contributing safety factor: a safety factor that, had it not occurred or existed at the time of an occurrence, then either: (a) the occurrence would probably not have occurred; or (b) the adverse consequences associated with the occurrence would probably not have occurred or have been as serious, or (c) another contributing safety factor would probably not have occurred or existed.

Other safety factor: a safety factor identified during an occurrence investigation which did not meet the definition of contributing safety factor but was still considered to be important to communicate in an investigation report in the interests of improved transport safety.

Other key finding: any finding, other than that associated with safety factors, considered important to include in an investigation report. Such findings may resolve ambiguity or controversy, describe possible scenarios or safety factors when firm safety factor findings were not able to be made, or note events or conditions which 'saved the day' or played an important role in reducing the risk associated with an occurrence.

Safety issue: a safety factor that (a) can reasonably be regarded as having the potential to adversely affect the safety of future operations, and (b) is a characteristic of an organisation or a system, rather than a characteristic of a specific individual, or characteristic of an operational environment at a specific point in time.

Risk level: the ATSB's assessment of the risk level associated with a safety issue is noted in the Findings section of the investigation report. It reflects the risk level as it existed at the time of the occurrence. That risk level may subsequently have been reduced as a result of safety actions taken by individuals or organisations during the course of an investigation.

Safety issues are broadly classified in terms of their level of risk as follows:

- **Critical** safety issue: associated with an intolerable level of risk and generally leading to the immediate issue of a safety recommendation unless corrective safety action has already been taken.
- **Significant** safety issue: associated with a risk level regarded as acceptable only if it is kept as low as reasonably practicable. The ATSB may issue a safety recommendation or a safety advisory notice if it assesses that further safety action may be practicable.
- **Minor** safety issue: associated with a broadly acceptable level of risk, although the ATSB may sometimes issue a safety advisory notice.

Safety action: the steps taken or proposed to be taken by a person, organisation or agency in response to a safety issue.

FACTUAL INFORMATION

History of the flight

On 19 July 2011 at 0738 Eastern Standard Time[1], a PZL-Mielec M18A Turbine Dromader aircraft, registered VH-FOZ, departed St George, Queensland (Qld) for a private airfield on a cotton station about 13 km west-south-west (WSW) of Dirranbandi, Qld to conduct a series of aerial application (spraying) flights. In addition to the pilot, the aircraft carried a passenger on the transit flight who was to act as mixer for the day’s operations. The mixer’s duties included mixing spray chemicals, loading the aircraft’s hopper and refuelling the aircraft.

After landing at the airfield, the pilot briefly discussed the day’s aerial application requirements with the farm manager. Those requirements included applying herbicide to irrigation channels around the cotton fields. The mixer pumped the mixed chemicals into the aircraft’s hopper and, at the pilot’s direction, refuelled the aircraft’s left wing fuel tank.[2] The mixer filled the hopper to the level of an external mark which had reportedly been made at the 2,600 L level. The pilot then conducted two spraying flights. After each flight, the mixer reloaded the aircraft’s hopper and filled one wing fuel tank as directed by the pilot.

At 1138, the aircraft took off for a third spraying flight. The mixer reported that he later dozed off and that, at about 1400, he attempted to contact the pilot by ultra-high frequency radio without success. He then telephoned the operator by mobile telephone to raise the alarm.

A search was initiated and the aircraft was located at about 1445 in a ploughed field on the station, 23 km WSW of Dirranbandi (Figure 1). The aircraft had impacted terrain. The pilot was fatally injured and the aircraft was destroyed by impact forces. There was no fire.

Later examination of on-board data recordings showed that the aircraft impacted the terrain at 1157.

1 Eastern Standard Time (EST) was Coordinated Universal Time (UTC) + 10 hours.

2 The aircraft was fitted with two wing fuel tanks that drained into a central collector tank, where the engine’s fuel pickup was located.

Figure 1: Aircraft wreckage

Personnel information

The pilot held a Commercial Pilot (Aeroplane) Licence that was issued in 1996 and a Class 1 Medical Certificate with no restrictions that was valid to 24 July 2011. He was endorsed to fly the Turbine Dromader and had completed an agricultural aeroplane flight check on 31 March 2011. The pilot had a total aeronautical experience of about 4,961 hours, including 74 hours on the Turbine Dromader (all of which was conducted in the previous 3 months) and over 700 hours on piston-engine Dromader variants. He had significant experience in other aerial work including mustering and aerial survey in a variety of aircraft types.

The pilot had been employed by the aircraft operator since March 2011 and had been appointed as Chief Pilot.

The pilot was reported to have been well-rested and in a good mood on the day of the accident with no significant medical conditions. A fellow pilot described the accident pilot's flying as 'very cautious'.

Aircraft information

General

The aircraft, serial number 1Z014-10, was manufactured in Poland in 1995 and first registered in Australia in 2004. It was a low-wing agricultural aircraft with seating for a pilot and one passenger (Figure 2). It was powered by a single Honeywell TPE331-11U turboprop engine, driving a 5-blade Hartzell constant-speed propeller via a reduction gearbox. The aircraft's hopper capacity was about 3,000 L with a maximum hopper load weight of 3,000 kg.

The aircraft was originally fitted with a nine-cylinder radial piston engine and 2,500 L hopper, with a maximum hopper load weight of 1,500 kg. Subsequent modifications approved by the US Federal Aviation Administration (FAA) and the Civil Aviation Safety Authority (CASA) in Australia permitted the aircraft to be modified with the installation of the TPE331-11U turboprop engine, and the 3,000 L hopper.

The aircraft was not fitted with a stall warning system, nor was one required to be fitted.

At the time of the accident, the aircraft was configured for aerial spraying using spray booms mounted below and behind the trailing edge of the main wings and an air-driven pump, externally-mounted below the fuselage. Laterally-opening doors, normally used for fire fighting, were attached to the base of the hopper and enabled the hopper contents to be jettisoned in an emergency.

Figure 2: Photograph of VH-FOZ

Photograph courtesy of Roger Syratt

Airworthiness and maintenance

The aircraft was certified for agricultural operations under the Restricted category.[3] The most recent maintenance release[4] and aircraft flight manual (AFM) were not located in the wreckage.[5] A copy of the AFM was later obtained from the operator.

[3] Under Civil Aviation Safety Regulation (1998) 21.025, a restricted category aircraft is one for certain special purpose operations, which include agricultural operations and firefighting.

[4] Official document, issued by an authorised person, that is required to be carried on an aircraft as an ongoing record of its time in service (TIS) and airworthiness status. Subject to conditions, a maintenance release is valid for a set period, nominally 100 hours TIS or 12 months from issue.

[5] Under Civil Aviation Regulation (1988) 139, an aircraft's maintenance release and AFM must be carried in an aircraft when the aircraft is flying.

According to maintenance records, the aircraft had accumulated about 5,901 hours total time in service (TTIS). The engine, serial number P-44208C, had accumulated 2,872.7 hours time since overhaul (TSO) and 22,155.8 hours TTIS. The Hartzell model HC-B5MP-5BL, serial number BUA2833 propeller had accumulated 758.4 hours TSO.

The most recent documented maintenance task carried out on the aircraft was a scheduled annual inspection and maintenance release issue that was completed on 29 June 2011. The maintenance release was valid until 29 June 2012 or 5,996.7 hours TTIS, whichever occurred first.

The investigation examined the aircraft's maintenance documentation and no deficiencies were identified that would affect normal flight. Since the maintenance release was not recovered, the investigation was unable to determine if there were any recorded outstanding defects.

On 15 January 2001, the aircraft manufacturer issued Service Bulletin E/02.172/2001 permitting an extension of the airframe retirement life from 6,000 to 10,000 flight hours. The extension could only be applied after several structural inspections and other maintenance tasks were completed. The aircraft was not certified as complying with that service bulletin.

Operations at increased weights

The aircraft was originally approved for a maximum take-off weight (MTOW) of 4,200 kg. An Australian Supplemental Type Certificate (STC SVA521) permitted operations at weights up to 6,600 kg with the use of an AFM supplement and a maintenance manual supplement.

Two non-mandatory AFM supplements (PZL Supplements 1 and 16) were available from the aircraft manufacturer and permitted operations at take-off weights up to 4,700 kg and 5,300 kg respectively. Those supplements provided various additional conditions, limitations, and information about operations above 4,200 kg.

The AFM for the aircraft included the flight manual supplement for STC SVA521. It did not include PZL AFM Supplements 1 or 16.

Relevant operating limitations from the AFM and supplements are detailed in Table 1. The supplement for STC SVA521 stated that the limitations in that supplement were 'applicable to all M18 [and] M18A aircraft operations at weights above 5300 kg up to a maximum of 6600 kg'.

Table 1: Operating limitations

	Included in the AFM		Not included in the AFM	
	Basic AFM#	**AFM Supp. for STC SVA521**	**PZL AFM Supp. No 1**	**PZL AFM Supp. No 16**
MTOW (kg)	4,200	6,600	4,700	5,300
Maximum hopper load (kg)	1,500	3,000	2,000	2,200
Never exceed speed, V_{NE}[6] (KIAS[7])	121	135	121	121
Maximum structural cruising speed, V_{NO}[8] (KIAS)	121	115	104	104
Maximum bank angle in turn	60º	15°	60º	15+5°
Maximum manoeuvring flight load factor[9]	-1.4 / +3.4 g	-0.9 / +2.25 g at 6,600 kg -1.1 / +2.8 g at 5,300 kg	-1.2 / +3.0 g	-1.1 / +2.8 g

Incorporating a supplement for the TPE331 engine installation.

Weight and balance

The AFM included a load data sheet to aid with assessing the aircraft's weight and balance. It contained a table with entries for the weight, arm, and moment of relevant items such as the empty aircraft, pilot, fuel, hopper load and other cargo. A fixed moment arm was indicated on the load data sheet for the hopper load, and a sample calculation made use of that moment arm. The investigation found that using this data sheet and fixed hopper moment arm, the aircraft's c.g. varied almost linearly with varying hopper load.

The AFM supplement for operations up to 6,600 kg included a chart enabling the aircraft's c.g. to be calculated using a variable moment arm for the hopper load. Using this variable moment arm method, the investigation found that the aircraft's c.g. varied significantly with hopper load. Ultimately, it was determined that the variance in the moment arm could result in the aircraft's c.g. moving outside of the aircraft's permitted weight and balance envelope as the hopper emptied, even if the c.g. was within the envelope during takeoff. This may lead to aircraft control

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6 V_{NE} is the maximum speed permitted under any circumstances.

7 KIAS is kts indicated airspeed.

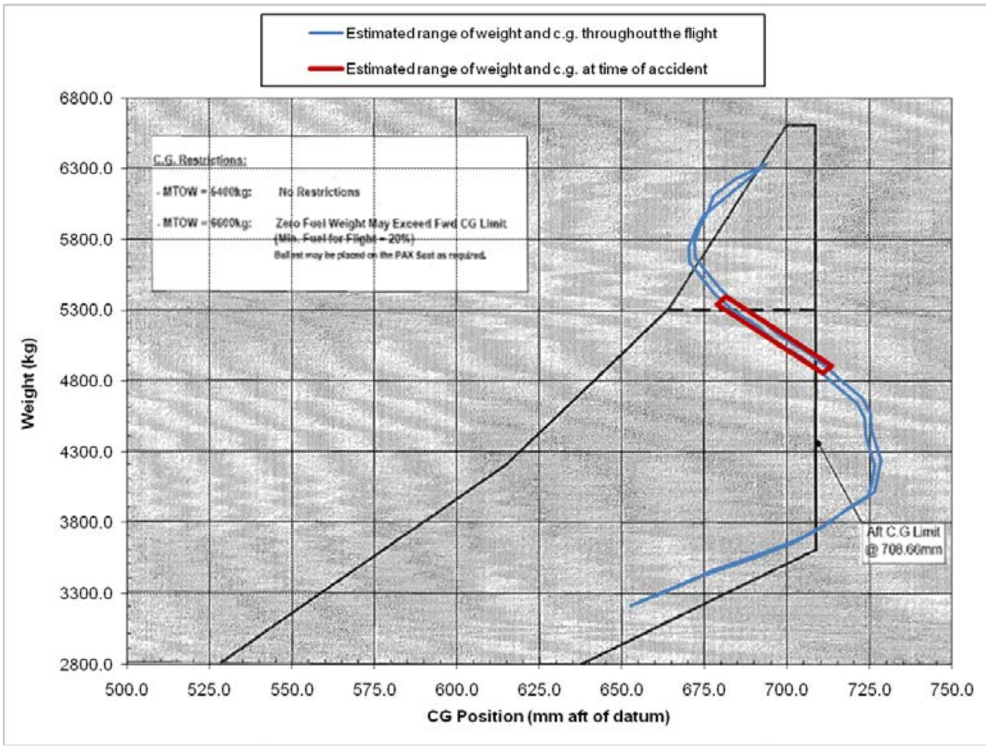
8 V_{NO} is the maximum speed for normal operating conditions that may only be exceeded in smooth air with caution.

9 G is the nominal value for acceleration. In flight, g-load values represent the combined effects of flight manoeuvring loads and turbulence. This can be a positive or negative value.

difficulties resulting from decreased stability and/or increased stall speeds, and possibly structural loads in excess of the design loads.[10]

A chart showing the estimated variation of the aircraft's weight and c.g. throughout the flight, overlaid on the approved weight and balance envelope, is shown in Figure 3.

Figure 3: Weight and balance estimates



The aircraft's weight and balance at the time of the accident could not be accurately determined as no record of fuel or chemical uplift was kept. However, using the fuelling procedure used by the mixer, and a hopper quantity determined from the level that the mixer reported to have used during replenishment, a range of possible take-off weights was determined. The fuel consumption and chemical application rates were then used to estimate the possible aircraft weight and balance at the time of the accident.

Based on those assumptions, the aircraft's weight was estimated to be between 5,945 kg and 6,367 kg at takeoff and between 4,853 kg and 5,397 kg at the time of the accident. Using that range of likely gross weights, it was estimated that the aircraft's weight and balance was most likely within or very close to the applicable weight and balance limits at the time of the accident (Figure 3, red plot).

Aircraft performance

The AFM supplement stated that the aircraft's stall speed at 6,600 kg with flaps retracted was 85 KIAS. The investigation estimated[11] that the aircraft's stall speed

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[10] See Federal Aviation Administration (2007), *Aircraft Weight and Balance Handbook*, FAA-H-8083-1A.

at the time of the accident was 73 to 77 KIAS in level flight at 1.0 g, and 107 to 111 KIAS at the peak recorded flight load of 2.1 g (see *On-board recording systems*, below).

Meteorological information

The Bureau of Meteorology (BoM) forecast for Dirranbandi indicated fine conditions with light to moderate south to south-easterly winds.

The nearest aerodrome for which an aerodrome forecast (TAF)[12] was available was for Moree, New South Wales, which was about 200 km east-south-east of the accident site. The Moree TAF that was issued at 1132 and valid from 1200 indicated a wind of 250° magnetic (M) at 12 kts and from 1500, a wind of 240° M at 15 kts, gusting to 25 kts.

BoM observations at St George, about 85 km north-east of the accident site, recorded south-westerly winds at 8 kts at 0900, and 13 kts at 1500. The maximum wind gust recorded at St George that day occurred at 1330 and was 21 kts from the west.

The mixer reported that the weather conditions on the day were cool, with little or no cloud cover and good visibility. He also recalled southerly winds of about 5 kts early in the day, increasing to 13 kts and gusting, as indicated by an anemometer at the airfield.

Wreckage and impact information

On-site information

The aircraft wreckage was lying in a flat, furrowed field about 240 m from the field's southern boundary. Ground impact marks and the distribution of the wreckage indicated that the aircraft had been on a northerly track, and impacted the ground in a slight left wing-low and nose-down attitude with a high sink rate.

The aircraft's fuselage came to rest about 50 m beyond the initial ground impact. The forward fuselage had separated at the hopper, forward of the cockpit. The propeller and gearbox had separated from the engine. Two of the propeller's five blades had separated during the impact sequence and the remaining three were severely bent against the direction of propeller rotation.

The soil in the vicinity of the wreckage was contaminated by a significant quantity of spilt fuel and application chemical. There was no evidence of any fuel or chemical spill or jettison prior to the initial ground impact.

A small number of items of wreckage originating from around the cockpit area were found between 50 m and 220 m to the south of the initial impact point. There was no indication to suggest that they separated from the aircraft prior to impact.

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11 The stall speeds were estimated using equation 3, chapter 27 of Wood, R. H. & Sweginnis, R. W., 2006. *Aircraft Accident Investigation.* 2nd ed. Wyoming, USA: Endeavour Books.

12 Aerodrome Forecasts are a statement of meteorological conditions expected for a specific period of time, in the airspace within a radius of 5 NM (9 km) of the aerodrome.

All of the aircraft's primary structure and flight controls were located within the accident site and there was no evidence of in-flight breakup or fire. There were no anomalies identified with the aircraft's flight control systems. There was also no evidence of birdstrike or previous impact with ground obstacles.

The aircraft was not fitted with an emergency locator transmitter, nor was it required to be by aviation regulation.

The impact was not considered survivable.

Aircraft component examinations

Propeller

The aircraft's propeller was removed from the accident site and examined at an approved maintenance facility under the supervision of the Australian Transport Safety Bureau (ATSB). The examination found no evidence of pre-existing anomaly with the propeller and determined that the propeller damage was the result of the ground impact while under significant power.

On-board recording systems

An aircraft data acquisition alarm monitor (DAAM) unit was recovered from the wreckage and sent to the unit's manufacturer in Brisbane, Qld for data download. An AG-NAV guidance system[13] was also recovered and taken to the ATSB's facilities in Canberra, Australian Capital Territory for technical examination.

Data was retrieved from both units. The parameters that were recovered from the DAAM unit included pressure altitude[14], indicated airspeed[15], flight load (g), propeller speed, engine torque, and fuel flow. The parameters obtained from the AG-NAV unit included the aircraft's location, height, groundspeed, and aerial application status (that is, whether the spray system was on or off).

There were no aircraft systems that recorded the aircraft's attitude, vertical speed or rotation about its axes. As a result, this information could only be inferred from other information and only to a limited extent.

Analysis of the recorded data showed that, on the day of the accident, the aircraft made three aerial application flights, including the accident flight. The first two were of about 48 and 50 minutes duration respectively, and the accident flight was of 18 minutes and 30 seconds duration.

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[13] The AG-NAV guidance system was a visual guidance tool that allowed pilots to spray precise patterns within a defined spray area using Global Positioning System (GPS)-derived position information.

[14] Height measured above a standard sea level reference plane of 1013.2 hPa.

[15] It was reported that the aircraft's DAAM unit displayed a higher airspeed than that shown on the aircraft's airspeed indicator. Analysis of the recorded data indicated that the recorded airspeed was about 5.7 kts higher than the actual airspeed. Recorded airspeeds provided in this report were adjusted accordingly. There was no regulatory requirement for the calibration of the DAAM airspeed.

The AG-NAV data was recorded up to about 14 seconds prior to the collision with terrain (Figure 4). At that time, the aircraft was in a climbing right turn having just completed a spray run on a south-westerly track. The radius of the turn was about 500 m, which could theoretically be accomplished by maintaining a bank angle of 39° and a flight load of 1.3 g throughout the turn.[16]

The DAAM unit stopped recording after the collision with terrain. Up to the last turn, the aircraft's recorded g-load varied between +0.4 and +1.7 g. About 4 seconds prior to the initial ground impact, the recorded g-load increased steadily over about 2 seconds, before momentarily peaking at +2.1 g. At this point, the recorded airspeed was 123 kts.

The g-load then dropped sharply and remained below +1.0 g, indicating a downwards acceleration to impact.

Figure 4: Accident site overview showing the recorded aircraft track (yellow), spray runs (blue) and the final part of the recorded track (orange)

© Google Earth

Engine torque for most of the flight was recorded at or above 94% and there was no significant variation in engine torque, fuel flow or turbine temperature throughout the flight.

The investigation analysed 73 turns made by the aircraft during the day's three flights, and estimated the minimum bank angle required to make each turn at the recorded speeds. The estimated angle of bank varied between about 20° and 60° during the turns and was between 30° and 45° for 51 of the turns.

The aircraft's recorded airspeed after takeoff on the accident flight varied between 110 and 142 kts, with an average of 128 kts. The aircraft exceeded 135 kts (the

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16 The angle of bank and g-load were estimated from the radius and speed of the turn using equations 12 and 13 from chapter 26 of Wood, R. H. & Sweginnis, R. W., op. cit.

aircraft's V_{NE} at weights above 5,300 kg) about 19% of the time and exceeded 115 kts (the aircraft's V_{NO} at weights above 5,300 kg) about 96% of the time.

Medical and pathological information

A post-mortem examination of the pilot indicated that the pilot succumbed to multiple impact-related injuries and did not identify any pre-existing medical conditions that may have contributed to the accident.

Toxicological testing detected carbon monoxide at a level within the normal range and no traces of drugs or alcohol.

Additional information

Previous accidents

VH-IGT, 29 December 2008

On 29 December 2008, a M18A Dromader (TPE331) aircraft, registered VH-IGT (IGT), impacted terrain while conducting spraying operations on a property near Nyngan, New South Wales. The pilot, who was the sole occupant, was fatally injured.

The investigation[17] found that the outboard 1.8 m of the right wing separated from the aircraft resulting in a loss of control and subsequent impact with the terrain. The separation of the right wing section could not be conclusively attributed to any particular factor.

During the course of the investigation, it was determined that a number of operators of the aircraft type were not applying the appropriate service life factors to determine the effective hours flown when their aircraft were operated at take-off weights above 4,700 kg. The effect was to overestimate the remaining service life of those aircraft.

It was also found that operators had an interpretation of the Civil Aviation Safety Authority (CASA) exemptions that, by their understanding, permitted operation at weights in excess of the maximum take-off weight and allowed them to operate at higher take-off weights without the need to account for the additional limitations imposed by the manufacturer for operation at those weights.

As a result of the accident, the following safety action was taken or proposed:

- The aircraft operator undertook a retrospective process of applying the service life factors to its aircraft fleet during operations that had involved take-off weights above 4,700 kg and planned to apply them to all relevant future flights.
- CASA advised that they had contacted Certificate of Registration holders of M18 Dromader aircraft to verify that they had procedures for recording and factoring aircraft hours that included overweight operations. Further verification would also occur as part of CASA's routine surveillance program. CASA also

17 See http://www.atsb.gov.au/publications/investigation_reports/2008/aair/ao-2008-084.aspx.

advised that they would provide education to operators on the intention of the exemptions and would revise the exemptions.

VH-FVF, 16 February 2006

On 16 February 2006, a turbine-engined M18A Dromader, registered VH-FVF, impacted terrain during fire-bombing operations near Cootamundra, NSW. The pilot was an experienced agricultural pilot with previous fire-bombing experience. Although he had considerable flying experience on radial-engine Dromader aircraft, and in other turbine agricultural aircraft, his total flying experience in the turbine-engined Dromader was 4.7 hours.

The ATSB investigation[18] found that the pilot lost control of the aircraft during a turn at low altitude and at a height that was insufficient to recover the aircraft to normal flight, and that the loss of control was most probably the result of an inadvertent aerodynamic stall.

Aerodynamic stall

An aerodynamic stall occurs when the normally smooth airflow over the upper surface of an aircraft's wing separates and becomes turbulent, resulting in a significant reduction of lift. This occurs when the angle between the wing and the relative airflow, known as the angle of attack, is approximately 16° to 18°. The angle of attack when this separation occurs is known as the stalling angle and it is the same for a particular aerofoil or wing section, irrespective of the airspeed.

An aircraft's stalling speed will vary from a minimum in level, gradually decelerating flight to higher values in accelerated stalls, which can occur during aircraft manoeuvring. The increase in stall speed is proportional to the square root of the aircraft's g-load. For example, in a level 60° banked turn, where the g-load is doubled (2 g), the stalling speed is increased by a factor of 1.4142, or nearly one and a half times its level flight stalling speed. The stall speed is also dependent on the aircraft's overall weight.

The stalling speeds published in an aircraft's AFM are obtained during certification trials by the aircraft manufacturer under flight test conditions and with a new aircraft. In practice, stalling speeds can be greater due to differences in pilot handling techniques and turbulence. Additionally, degradation of wing shape as a result of minor damage and repairs, aircraft rigging and externally-mounted equipment can result in a stall speed greater than the published speeds.

18 See http://www.atsb.gov.au/publications/investigation_reports/2006/aair/aair200600851.aspx.

ANALYSIS

Introduction

No evidence of any mechanical fault with the aircraft that could have contributed to the accident was found. The recorded data and propeller examination indicated that the engine was producing significant power at the time of the accident, and the aircraft was most likely within applicable weight and balance limits at that time. A post-mortem examination of the pilot did not identify any pre-existing medical conditions that may have contributed to the accident. The weather was considered not to be a factor in the accident.

In that context, this analysis will examine the factors in this accident with the potential to increase the risk associated with similar operations in the future.

Accelerated stall

The recorded g-load data was consistent with that of an aircraft experiencing an aerodynamic stall while being manoeuvred. Additionally, the aircraft angle and attitude at impact was consistent with that resulting from an attempted recovery from a stall at low altitude.

Although the recorded airspeed at the commencement of the descent was 12 to 16 kts above the calculated stall speed at the applicable g-load, factors such as handling, wing shape, rigging, and variation from the estimated aircraft weight could result in a higher stalling speed. Despite this uncertainty, and the limitations of the recorded data, the investigation considered that an accelerated stall remained a possibility.

Distraction

The investigation considered the possibility of the pilot being distracted, increasing the risk of an aerodynamic stall or other unintended manoeuvre. For example, addressing a failure of the aircraft's AG-NAV guidance system or other problem may have absorbed the pilot's attention, adversely affecting his control of the aircraft.

However, whereas pilot distraction is an ongoing risk, particularly during low–level operations, there was no evidence to support or refute its contribution to this accident.

Aircraft flight manual

The aircraft flight manual (AFM) included a set of operating limitations for weights up to 4,200 kg, and a supplement that included further operating limitations for weights between 5,300 kg and 6,600 kg. However, it was found that the information provided to pilots could be interpreted in such a way that either set of limitations could have applied to the intermediate weights.

Two supplements were available from the aircraft manufacturer relating to operations at weights between 4,200 kg and 5,300 kg. While those supplements were not mandatory, they provided operating limitations determined by the aircraft manufacturer to ensure the safety of flight when operating in that weight range. Their inclusion in the AFM would have mandated the limitations within those supplements and given pilots clearer and more appropriate information for operations between those weights.

Effects of exceeding operational limitations

The aircraft was exceeding its maximum structural cruising speed at the time of the accident. It may also have exceeded the maximum bank angle permitted by the AFM. The recorded information showed that throughout the day's flights, the aircraft frequently exceeded both of these limitations as well as the aircraft's published never-exceed speed.

Exceeding any operational limitations can affect an aircraft's handling and performance, reducing the normal operational safety margins. It can also impose significant structural loads in excess of the aircraft's design loads, reducing the aircraft's effective service life and potentially causing structural failure.

The investigation found no evidence of in-flight structural failure and was unable to establish the extent to which exceeding the AFM limits affected the aircraft's handling and performance characteristics. Accordingly, it was not possible to determine whether exceeding those limits contributed to the accident.

Weight and balance

Normally, a check of an aircraft's zero fuel weight, take-off weight, and landing weight, with the implicit assumption that the aircraft's weight would vary almost linearly between these points, could be expected to meet the requirement to establish that an aircraft was within weight and centre of gravity (c.g.) limits throughout a flight.

However, when the variable moment arm of the hopper was taken into account, the aircraft's c.g. could move a considerable distance forward and aft. This effect could not be readily seen without carrying out multiple calculations. Recognition of its effect would be further complicated by varying hopper load densities and the relative rates of fuel and hopper load usage throughout a flight. Due to these difficulties, a reliable assessment of the aircraft's c.g. as it changes throughout a typical application flight would have been impractical, time-consuming and error-prone.

FINDINGS

From the evidence available, the following findings are made with respect to the collision with terrain of PZL-Mielec M18A Turbine Dromader aircraft, registered VH-FOZ, about 23 km west-south-west of Dirranbandi, Queensland on 19 July 2011. They should not be read as apportioning blame or liability to any particular organisation or individual.

Contributing safety factors

- For reasons that could not be definitively determined, the aircraft departed from controlled flight during a turn at low altitude and the pilot was unable to recover before impact with the ground.

Other safety factors

- Prior to and at the time of the accident, the aircraft was operated at airspeeds and bank angles exceeding the limitations in the aircraft flight manual.
- The flight manual for this aircraft did not include the aircraft manufacturer's supplements for operations at weights between 4,200 kg and 5,300 kg and as a result, did not provide the most appropriate information for pilots to conduct safe operation between those weights.
- The aircraft's centre of gravity varied significantly with hopper weight and could exceed the forward and aft limits at different times during a flight. *[Significant safety issue]*

Other key findings

- The aircraft was probably within its weight and balance limits at the time of the accident.

SAFETY ACTION

The safety issues identified during this investigation are listed in the Findings and Safety Actions sections of this report. The Australian Transport Safety Bureau (ATSB) expects that all safety issues identified by the investigation should be addressed by the relevant organisation(s). In addressing those issues, the ATSB prefers to encourage relevant organisation(s) to proactively initiate safety action, rather than to issue formal safety recommendations or safety advisory notices.

All of the responsible organisations for the safety issues identified during this investigation were given a draft report and invited to provide submissions. As part of that process, each organisation was asked to communicate what safety actions, if any, they had carried out or were planning to carry out in relation to each safety issue relevant to their organisation.

Aircraft centre of gravity

Significant safety issue

The aircraft's centre of gravity varied significantly with hopper weight and could exceed the forward and aft limits at different times during a flight.

Action taken by the Australian Transport Safety Bureau

On 6 December 2011, the Australian Transport Safety Bureau advised the Civil Aviation Safety Authority (CASA) of the potential for excessive movement of the aircraft's centre of gravity (c.g.) as the payload in the hopper is dumped or dispensed. The ATSB also brought the safety issue to the attention of the Aerial Agricultural Association of Australia on 16 December 2011.

Action taken by the Civil Aviation Safety Authority

On 22 December 2011, CASA distributed a letter to operators of the M18, M18A, and M18B Dromader advising of the potential unusual movement of the aircraft's c.g. as the payload in the hopper is dumped or dispensed. The letter also advised operators to assess the weight and balance of their aircraft, develop new loading systems if necessary, and ensure that all pilots are familiar with the aircraft loading systems and the potential for c.g. variation.

Action taken by the Supplemental Type Certificate holder

On 12 January 2012, the owner/developer of the Supplemental Type Certificate (STC) that permitted operations up to 6,600 kg take-off weight advised the ATSB that the design would be reviewed to assess and address any excessive c.g. variation that may occur as the result of hopper payload and fuel usage during a flight. In addition, they planned to advise all operators using the STC of the potential for excessive c.g. variation.

ATSB assessment of actions

The ATSB is satisfied that the actions taken and proposed by CASA and owner/developer of the STC will, when complete, adequately address the safety issue.

APPENDIX A: SOURCES AND SUBMISSIONS

Sources of information

The sources of information during the investigation included the:

- aircraft manufacturer
- aircraft operator
- owner/developer of Supplemental Type Certificate (STC) SVA521
- Bureau of Meteorology
- Civil Aviation Safety Authority (CASA)
- Queensland Police Service
- Queensland Coroner.

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 the aircraft operator, the owner/developer of the STC, an engineering organisation involved in the development of the STC, and CASA.

Submissions were received from the aircraft operator. The submissions were reviewed and where considered appropriate, the text of the report was amended accordingly.

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Investigation

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Aviation Occurrence Investigation
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