



**STATE CORONER'S COURT
OF NEW SOUTH WALES**

Inquest: Inquest into the death of David Black

Hearing dates: 27 February 2017 to 1 March 2017, 6 March 2017

Date of findings: 13 March 2017

Place of findings: NSW State Coroner's Court, Glebe

Findings of: Magistrate Derek Lee, Deputy State Coroner

Catchwords: CORONIAL LAW – aviation, non-destructive testing, eddy current inspection, magnetic particle inspection, M18 Dromader, airworthiness directive, CAR 2A approval, Australian Transport Safety Bureau (ATSB), Civil Aviation Safety Authority (CASA)

File number: 2013/322207

Representation: Mr A Casselden SC, Counsel Assisting, instructed by Ms M Katawazi (Office of the General Counsel)

Mr D Lloyd instructed by GSG Legal (Mrs Julie Black and the children of David Black)

Mr J Ribbands instructed by Maitland Lawyers (Aviation NDT Services Pty Ltd, Mr Travis Tuck & Mr Neil Joiner)

Mr R Clifford instructed by Sam Hegney Solicitors (Beal Aircraft Maintenance, Mr Donald Beal & Mr Bruce Beal)

Mr P Hornby (Australian Transport Safety Bureau)

Mr A Carter (Civil Aviation Safety Authority)

Non-publication orders: Pursuant to section 74(1)(b) of the *Coroners Act 2009* and section 60(7) of the Transport Safety Investigation Act 2003, the ATSB PowerPoint presentation titled, "ATSB In-flight breakup involving a PZL Mielec M18A Dromader", is not to be published.

Findings:

I find that David Black died on 24 October 2013 in an area of the Budawang National Park, about 37km west of Ulladulla, New South Wales. The cause of death was multiple injuries, which Mr Black suffered when the aircraft that he was piloting impacted terrain following an in-flight separation of the aircraft's left wing. The wing separation was caused by corrosion pitting and fatigue cracking in the lower left wing attachment fitting leading to the fracture and critical failure of the attachment lug.

Recommendations:***To the Civil Aviation Safety Authority:***

- (a) I recommend that consideration be given to the issuing of an airworthiness directive pursuant to regulation 39.001 of the *Civil Aviation Safety Regulations 1998* requiring that visual inspections and magnetic particle inspections of the wing attachment joints of M18 Dromader aircraft, and its variants, be performed with the outboard wings removed.

- (b) I recommend that consideration be given to the issuing of an airworthiness directive pursuant to regulation 39.001 of the *Civil Aviation Safety Regulations 1998*, or a direction given under regulation 43 of the *Civil Aviation Regulations 1988*, that aircraft factored time in service should be recorded on all maintenance releases in order to accurately determine an aircraft's time in service for service life limitation considerations and maintenance scheduling purposes.

Table of Contents

Introduction.....	1
Why was an inquest held?	1
David's life	1
What happened on 24 October 2013?	2
What investigation was conducted after the accident?	3
What do we know about VH-TZJ and its history prior to the accident?	4
What caused the wing to separate in-flight?.....	4
How was TZJ's aircraft fatigue managed?	5
What is non-destructive testing?	6
What significant events occurred in the year 2000?	6
What maintenance, inspection and testing procedures were in place for TZJ?	7
(a) What were the two procedures?	8
(b) Which procedure was submitted to, and approved by, CASA?	8
(c) What was the effect of the approval?.....	12
What occurred during the inspection of TZJ on 8 August 2013?.....	14
Was the August 2013 inspection adequate?	15
(a) Was corrosion pitting present?.....	15
(b) Was fatigue cracking present?	16
(c) Why was the corrosion pitting not removed and the fatigue cracking not detected?.....	16
Should any recommendations be made?.....	18
(a) Removal of aircraft wings during inspection	18
(b) Service life factoring of aircraft	19
(c) Pre-2009 service life factoring	19
(d) Auditing conducted by CASA airworthiness inspectors.....	20
(d) Continuing education for licensed aircraft maintenance engineers	21
Findings.....	21
Identity	22
Date of death.....	22
Place of death.....	22
Cause of death	22
Manner of death.....	22
Recommendations	22
Epilogue.....	22

Introduction

2. On 24 October 2013 David Black was flying an agricultural aircraft in an area of national park in the south coast region of New South Wales carrying out firebombing duties for the Rural Fire Service. He was doing something which he loved to do and, at the same time, performing an important and valuable civic service. As David was about to embark on a firebombing run the left wing of his aircraft separated, causing the aircraft's rapid descent and an unsurvivable impact with the ground below.

Why was an inquest held?

3. All unnatural deaths are reportable to a Coroner. When a person's death is reported there is an obligation on the Coroner to investigate matters surrounding the death. This is done so that evidence may be gathered to allow a Coroner to answer questions about the identity of the person who died, when and where they died, and what the cause and the manner of their death was. The manner of a person's death means the circumstances in which that person died.
4. In David's case, there is ample evidence to establish his identity, where and when he died, and what the medical cause of his death was. The inquest primarily focused on the manner of David's death. That is, what caused the wing separation during flight, and what were the circumstances which lead to that catastrophic event.
5. The inquest focused on two main issues, namely:
 - (a) Whether the inspection, maintenance and testing procedures in relation to David's aircraft, including the wing fittings, were implemented and followed; and
 - (b) Whether the inspection, maintenance and testing procedures in relation to David's aircraft, including the wing fittings, were adequate.
6. As a Coroner also has the power to make recommendations to improve public health safety in order to reduce the possibility that a similar death might happen in the future, the inquest also examined whether any such recommendations could be made arising from the investigation into David's death.

David's life

7. The inquest necessarily examined a number of complex and technical aspects associated with aircraft maintenance and engineering. In the midst of such evidence there is the potential to lose sight of the person at the centre of the inquest and how his family and friends have been affected by his tragic loss.
8. For that reason it is extremely important to briefly say something about David's life, as well as to recognise and acknowledge the tremendous pain and grief that his passing has caused to his family and those who knew him well.
9. At the conclusion of the evidence in the inquest the court was privileged to hear some heartfelt and moving words spoken by David's wife, Julie, and David's parents, Sarah and Andrew. I

convey my appreciation and thanks to them for sharing their treasured and private memories of David. Their words were both poignant and uplifting at the same time.

10. After completing high school David studied mechanical engineering but later discovered one of his passions in life: flying. By working on his family's property he paid for flying lessons and later obtained his pilot's licence.
11. David later met his wife of 12 years, Julie, and together they worked hard for many years to grow a small business venture into a successful and thriving aerial application company. This company provided valuable private and public services to the agricultural industry, as well as to rural communities in NSW in general. At all times, David remained true to his principles and was well-respected and highly regarded for his professionalism, fairness and work ethic.
12. David very much enjoyed the company of his immediate, and extended, family, as well as that of his many friends. He enjoyed music and a lively party, appreciated good food and had a particular weakness for junk food. No doubt his family and friends will miss his enthusiastic and cheerful presence at future gatherings.
13. It is distressing to know that David's passing occurred at a time when he was in the prime of his life, leaving behind his and Julie's three young children. David and Julie had worked together as a team, industriously, to reach a stage in life where their business was successful, their family was nurtured and cared for, and they were able to simply enjoy life. To lose David in tragic and sudden circumstances is heartrending. Julie's strength, courage and resilience is worthy of admiration.

What happened on 24 October 2013?

14. On 19 October 2013 a fire broke out in the Budawang National Park, an isolated and mountainous area about 37km west of Ulladulla. Officers from the NSW National Parks and Wildlife Service developed strategies to contain the fire line by using fixed wing aircraft and helicopters to bomb the fire ground. This process involves the deployment of fire retardant from the air to the ground in order to contain the spread of the fire. Bombing runs were conducted between 19 October 2013 and 23 October 2013.
15. David owned and operated a company, Rebel Ag, that provided aerial application services to the agricultural industry. Part of Rebel Ag's services was also to provide aerial support to the NSW Rural Fire Service. At the time of the fire Rebel Ag had a fleet of 14 aircraft, one of which was aircraft registration VH-TZJ (**TZJ**). On 21 October 2013 David flew TZJ from the headquarters of Rebel Ag at Trangie airport to Nowra. David conducted three firebombing missions that day, and another six missions on the following day, 22 October 2013.
16. At about 9:40am on 24 October 2013 David took off in TZJ¹ from Nowra airport to conduct a firebombing mission about 62km to the southwest. David had already undertaken a brief flight about 20 minutes earlier at 9:22am in order to dispose of water which had been stored in the aircraft's hopper overnight, before returning to the airport so that it could be loaded with fire retardant. Another firebombing aircraft with one pilot, and a support helicopter with two crew and one observer, were also involved in the mission.

¹ On this day the aircraft has been allocated the call sign bomber 295.

17. Once the bombing team reached the area of fire, being near the north area of a ridgeline, the support helicopter marked the target area by hovering overhead. David acknowledged the marked target location and advised the team of his intended flight path.
18. David manoeuvred his aircraft to approach from the south east with the intention to attack the north western corner of the fire. He was flying in a southerly direction and made a wide turn to the south of the target fire, moving around from west to east. David completed his final turn in order to start his run to the target fire and had just levelled out, approximately 100 feet above the tree line, for a straight approach to the target area.
19. As TZJ levelled out, or immediately afterwards, the left wing of the aircraft folded up and detached from the fuselage.² This had the catastrophic effect of causing the aircraft to roll to the left, invert, and rapidly descend, impacting with terrain. The aircraft sustained significant damage and David was fatally injured. The accident occurred at about 10:04am.

What investigation was conducted after the accident?

20. Dr Riannie Van Vuuren Bailey, forensic pathologist, performed the postmortem examination on 25 October 2013 at the Department of Forensic Medicine in Glebe. She found that the cause of death was multiple injuries.³
21. In the days and months that followed the accident, investigators from the local police and from the Australian Transport and Safety Bureau (**ATSB**) conducted a lengthy and comprehensive investigation into the circumstances of the accident. Evidence was collected from the wreck site and later analysed, statements were taken from witnesses, and documentary records relating to TZJ's operational and maintenance history were collected and reviewed. On 15 February 2016 the ATSB published its final report and identified a number of safety issues arising from the accident, and actions taken since the accident to address these issues.
22. It should be noted that the inquest was not meant to duplicate the work of the ATSB nor review its investigation and findings. The ATSB report identified a number of safety issues relating to the accident, as well as the safety actions taken by the relevant organisations to whom the safety issues related. As most of the safety issues have, to date, been satisfactorily addressed, or are in the process of being addressed, the inquest only focused on specific issues which the ATSB investigation was unable to consider. Mr Paul Ballard, the ATSB principal investigator, gave evidence at the inquest in order to explain aspects of the ATSB investigation and the ATSB final report. At the inquest no issue was taken with any aspect of Mr Ballard's evidence nor with the contents of the ATSB report. Mr Ballard and his investigation team should be commended for the thorough and detailed investigation which they conducted.
23. Given the comprehensive nature of the ATSB investigation and the amount of detail to be found in the 104-page ATSB final report I do not propose, in these findings, to repeat matters contained in the report except where they specifically relate to the issues which the inquest investigated. Where I have done so, I have drawn from and summarised the detail contained in the report.

² Exhibit 1, pages 69, 81.

³ Exhibit 1, tab 5.

What do we know about VH-TZJ and its history prior to the accident?

24. The aircraft that David was flying is a variant of the M18 Dromader. This is a low-wing, single or two-seat, agricultural aircraft, designed and manufactured by Polskie Zaklady Lotnicze (**PZL**) Co Ltd in Poland. There are three main variants: the M18, M18A, and M18B. VH-TZJ was the M18A variant and was manufactured in 1984. David's company purchased TZJ and it was imported into Australia in 2004 in a disassembled condition and later reassembled.
25. Little is known about the aircraft's 20 year history prior to import other than it had a recorded total time in service⁴ of 3,031.4 hours at the time that it was imported. Serviceable wings from another M18 aircraft (registration VH-TGH) were fitted to TZJ and at this time it was reported that the attachment fittings on the wings were also replaced. According to the logbook for VH-TGH, the replacement wings had a total time in service of 3,021 hours.
26. TZJ was later modified to, amongst other things, increase the capacity of the hopper to 3,028L and to replace its piston engine and four-blade propeller with a turboprop engine and five-blade propeller.
27. M18 aircraft have a cantilever wing⁵ consisting of three sections: the centre wing section, and left and right outboard wing sections. The outboard wings are attached to the centre section at three points: an upper and lower attachment point located on the wing's main spar⁶, and a third attachment point on the rear spar. The upper and lower attachment points on the main spar consist of an inboard fitting, attached to the centre wing section, and an outboard fitting, attached to the outboard wing section.
28. A single lug on the outboard fitting is secured between the two lugs on the centre wing. The lugs are secured using an expandable mandrel. When the bolt through the mandrel is tightened, the mandrel expands to fill the bore of the lugs and prevent movement in the joint. The mandrel is designed to transfer loads from the outer wing fitting to the centre wing fitting. This, however, means that because there are no secondary load paths, failure of an attachment fitting will result in the loss of an aircraft's structural integrity.

What caused the wing to separate in-flight?

29. Initial examination at the impact site by the ATSB revealed that the outboard left wing had separated at the centre-to-outboard lower wing attachment joint. This was caused by a fracture in the left outboard wing lower attachment lug.
30. The ATSB discovered that corrosion pitting had formed in the bore, or inner surface, of the left outboard lower attachment lug. Corrosion pitting is a type of localised corrosion that creates cavities, or pits, in the surface of a metal. Inspection of the separated pieces of the lug revealed that fatigue cracks had formed in the lug at locations corresponding to the location of the corrosion pitting. Fatigue cracks form when a metal is subject to repeated varying stresses. Each time a tensile stress is applied the crack grows larger on a microscopic scale. When the crack reaches a critical size the remaining material is unable to withstand the applied stress and the remaining material rapidly fractures.

⁴ The total accumulated amount of hours that an aircraft is in flight between take-offs and landings.

⁵ A wing structure attached directly to the fuselage which does not have any type of external, stress-bearing structures.

⁶ A beam which takes the load along the wing, from wing tip to fuselage.

31. In the case of TZJ, the fatigue cracks in the lug joined to form a single fatigue crack which grew until the lug fractured during flight. The fracture surface of the lower lug revealed two distinct regions: a smooth area of progressive crack growth that originated in the inner bore of the lug; and a rough area of rapid fracture that corresponded to the final failure of the lug.
32. The ATSB investigation eliminated the possibility that a mechanical defect with the aircraft or weather conditions on 24 October 2013 had caused the in-flight wing separation. Furthermore, pilot error had no part to play at all in the accident. At the time of the accident David was a very experienced pilot who had held a relevant licence since 2003 and had been the Chief Pilot for Rebel Ag since 2012. According to logbook entries, David had accumulated just over 9,500 hours flying time, including almost 230 hours in firebombing. Contrary to an unwarranted and equivocal submission made at the end of the inquest by counsel for Beal Aircraft Maintenance, there is no evidence to suggest that David was not flying TZJ skilfully and carefully, as he had done many times previously, on 24 October 2013.

How was TZJ's aircraft fatigue managed?

33. In order to understand how the fatigue crack in the lug could have developed over time it is necessary to understand how aircraft fatigue is managed in general, and how it was managed for TZJ in particular.
34. In their report⁷ the ATSB explained that whilst the operation of an aircraft naturally causes stresses in the structure of the aircraft, they are designed in a way that these stresses do not exceed the strength of the materials that the aircraft is constructed from. However, fluctuation in the stresses can cause damage to the materials. Even though each incident of damage may be small, the accumulation of damage over time can result in significant damage. This accumulated damage is referred to as fatigue damage.
35. PZL used a safe-life design approach for managing aircraft fatigue in the M18 and its variants. This approach involves having the aircraft retired before there is a likelihood of cracks affecting the aircraft's structural strength. In order to determine when the aircraft should be retired, PZL calculated a service life, measured in hours, in which cracking from fatigue was unlikely to affect the aircraft's strength. Once the M18 and its variants reached the limitation of the service life, the aircraft is required to be retired from service.
36. According to its M18 Structural Repair Manual, PZL had calculated that the service life for the airframe of the M18 and its variants was 6,000 hours time in service. However the application of various manufacturer service bulletins, requiring certain modifications and additional inspections, allowed this limit to be extended to a maximum of 10,000 hours. While the airframe was subject to this service life limitation, PZL did not apply any specific limitation to the centre-to-outboard wing attachment fittings.
37. Apart from calculating how long TZJ had been in service, it was routinely inspected as part of its ongoing maintenance process by a licensed aircraft maintenance engineer (**LAME**). During these inspections non-destructive testing (**NDT**) was performed by a NDT technician. This

⁷ Exhibit 1, pages 157-158.

maintenance and testing was designed to, amongst other things, ensure the integrity of the aircraft's materials, parts and components.

What is non-destructive testing?

38. NDT is a process where the properties of materials, parts or components are inspected and evaluated for discontinuities or differences in characteristics. The testing is done in a way that does not damage or destroy their serviceability. There are several different methods of NDT but the methods relevant to the matters which the inquest examined are magnetic particle inspection (**MPI**) and eddy current inspection.
39. MPI is used to identify surface and near surface discontinuities in ferromagnetic materials such as steel and iron. The method involves the application of magnetic fields to a part or component which will be distorted if a discontinuity, such as a crack, is present.⁸
40. Eddy current inspection is a method where electrical currents are generated in a conductive material by an induced magnetic field. Imperfections in the material, such as cracks, will distort the flow of the electric current (eddy currents) and cause changes in the magnetic field.⁹

What significant events occurred in the year 2000?

41. On 18 June 1999 in the United States an M18A aircraft was heavily damaged in a non-fatal incident when its right wing separated in flight. Almost 12 months later on 22 May 2000 a different M18A aircraft, also in the United States, was destroyed in another non-fatal incident when its right wing also separated in flight. Subsequent investigation of both incidents by the United States National Transportation Safety Board (**NTSB**) revealed that the wing separations were caused by fatigue cracking in the right wing attachment lugs of each aircraft and that corrosion pitting was present in the lugs.
42. In response to the first incident the United States Federal Aviation Authority (**FAA**) issued Special Airworthiness Information Bulletin (**SAIB**) CE-00-13 on 20 January 2000. This SAIB encouraged M18 operators to inspect their aircraft in accordance with existing M18 service information. Following the second incident the FAA released SAIB CE-00-27 on 11 July 2000 to alert M18 operators of possible corrosion and cracks in the centre-to-outboard wing attachment fittings. The FAA recommended that the fittings be inspected using a magnetic particle method of inspection, or equivalent, after the first 3,000 hours time in service, and every 500 hours thereafter.
43. On 3 August 2000 PZL issued service bulletin E/02.170/2000¹⁰ (**the PZL service bulletin**) the purpose of which was to "*stress the need and necessity of anti-corrosion means application for periodic corrosion protection*".¹¹ The service bulletin noted that "*it is particularly critical to maintain good condition of the centerwing-to-outboard wing attachment joints*". It relevantly noted that as part of the joints inspection procedure:

- *Prior to elimination of corrosion, all joints found to be corrosion-affected must be inspected for possible cracks;*

⁸ Exhibit 1, page 23-13.

⁹ Ibid.

¹⁰ Exhibit 1, tab 31.

¹¹ Exhibit 1, page 1666.

- *The only acceptable inspection method is magnetic cracks detection*¹² [original emphasis];
- ...
- *Surfaces of the dia. 36mm holes can be inspected by magnetic cracks detection method with no need for outboard wing removal upon expansion mandrels removal (make sure to properly support the wing for operation)* [original emphasis].

44. The ATSB later asked PZL whether the mating faces and bores of each lug needed to be visually inspected and how this might be accomplished without removing the wings. PZL replied by advising that the aircraft's maintenance manual stipulated inspection of the centre wing-to-outboard wing attachment joints, which effectively meant the inspection of "everything". PZL also acknowledged that, whilst it was not specifically recommending wing removal, performing magnetic particle inspection without wing removal would be "troublesome and difficult".¹³
45. On 5 September 2000 the FAA issued airworthiness directive AD 2000-13-12 which became effective on 27 September 2000. It required that upon reaching 3,000 hours time in service, and at 500-hourly intervals thereafter, the M18 wing attachment fittings be inspected and repaired as necessary in accordance with the PZL service bulletin. It also specifically stated that MPI had to be the method of inspection.
46. On 19 October 2000 the Civil Aviation Safety Authority¹⁴ (**CASA**) issued airworthiness directive AD/PZL/5 (**the CASA AD**) which became effective on 25 October 2000. An airworthiness directive (**AD**) is a legislative instrument issued by CASA under regulation 39.001 of the *Civil Aviation Safety Regulations 1998*. The AD may be issued for an aircraft if an unsafe condition exists in an aircraft of that kind, and the condition exists, or is likely to exist, or could develop, in other aircraft of that kind. The AD requires that action necessary to correct the unsafe condition be taken at the time, or in the circumstances, mentioned in the AD.
47. The CASA AD applied to all M18 models and required inspection of the centre wing to outboard wing attachment joints by magnetic particle inspection in accordance with the PZL service bulletin. After each inspection, in the case of cracking being detected, the wing attachment joints were to be replaced. Complying with the CASA AD required inspection to be done upon an aircraft accumulating 2,500 hours total time in service, or before 19 November 2000, whichever occurred later.

What maintenance, inspection and testing procedures were in place for TZJ?

48. Some 11 weeks prior to the accident, TZJ was last inspected on 8 August 2013. One of the main issues that the inquest examined was what maintenance, inspection and testing procedure were in place for TZJ at this time.
49. The inspection on 8 August 2013 was carried out by Beal Aircraft Maintenance (**BAM**), a company owned by Mr Bruce Beal. Mr Beal's father, Mr Donald Beal, was a LAME employed by BAM at the time and he was involved in the inspection process. As part of this process BAM utilised the services of a NDT company, Aviation NDT Services Pty Ltd (**Aviation NDT**). The owner of Aviation NDT, Mr Travis Tuck, performed the NDT inspection of TZJ.

¹² It was accepted at the inquest, and there was no evidence gathered during the ATSB investigation to the contrary, that the reference to "magnetic cracks inspection" meant magnetic particle inspection.

¹³ Exhibit 1, page 171.

¹⁴ An independent statutory authority whose primary function is to conduct the safety regulation of civil air operations in Australia and the operation of Australian aircraft overseas.

50. Aviation NDT was incorporated in 2007 when Mr Tuck purchased the business from Mr Neil Joiner. Under Mr Joiner's ownership the company was previously known as Australian NDT Services Pty Ltd (**Australian NDT**).
51. In order to understand the circumstances which lead to the events of 8 August 2013, it is necessary to examine the events of September 2000. At that time, Mr Joiner (as the owner of Australian NDT) submitted an application to CASA for a particular type of eddy current NDT to be approved for inspection of M18 Dromader aircraft. The ATSB investigation discovered that the procedure found in records kept by CASA was different to the procedure produced by both Australian NDT and Aviation NDT. Much of the evidence at the inquest focused on which of the two procedures was submitted to, and approved, by CASA, and what was the effect of the approval.

(a) What were the two procedures?

52. One of the procedures is titled "Eddy Current Testing Procedure for Dromader M18 Centre Section Attachment Joints" and is dated 8 September 2000. It is described as Issue 2 of Procedure No: QP.00.36(E) (**the E procedure**).¹⁵ It is 10 pages in length and has been prepared on the letterhead of "Aviation NDT Services P/L" and the first page indicates that it has been approved by "N Joiner" but not signed. The E procedure referred to the use of a motorised rotating probe to perform the procedure, with less than 40% full-scale deflection as the acceptance criteria.
53. The other procedure is titled "Eddy Current Testing of the Main Wing (Centre Section) Attachments Joints" and is dated 8 September 2000. It is described as Issue 2 of Procedure No: QP.00.36(EC) (**the EC procedure**).¹⁶ It is 7 pages in length and has been prepared on the letterhead of Australian NDT Services P/L" with the first page indicating that it has been drafted by "N Joiner" and is signed. The EC procedure referred to the use of a manual probe with adjustable collar to perform the procedure, with less than 10% full-scale deflection as the acceptance criteria.

(b) Which procedure was submitted to, and approved by, CASA?

54. During the course of the inquest the entirety of the CASA file in relation to the approval procedure was produced and tendered into evidence.¹⁷ The file is 46 pages in length and contained copies of the following documents:
- the PZL service bulletin;
 - the EC procedure;
 - Issue 1 of the EC procedure dated 5 September 2000;

¹⁵ Exhibit 1, tab 32.

¹⁶ Exhibit 1, tab 33.

¹⁷ Exhibit 4.

- an email dated 11 September 2000 (**the September 2000 email**) from Len Bichard (the internal NDT technician for CASA at the time) to David Villiers (the CASA Section Head of Airframes at the time);
 - a letter dated 11 September 2000 (**the September 2000 letter**) from Mr Villiers to Australian NDT; and
 - the first FAA SAIB.
55. In evidence, Mr Joiner explained that sometime around August 2000 he became aware of both the PZL service bulletin and that a pending AD was soon to be issued by CASA. In response to both matters, Mr Joiner began developing a procedure for NDT of the wing attachment joints to be performed using the eddy current method of inspection, as opposed to MPI which was to be later required by the CASA AD. Mr Joiner estimated that he developed between 5 and 7 versions of the procedure before it was eventually approved by CASA. He said that he ultimately created a version of the procedure, which was identified as Issue 3, and that it was sent to CASA on the afternoon of 11 September 2000. After making amendments requested by CASA, the procedure was re-titled Issue 2 and approved. That approved procedure, said Mr Joiner, was the E procedure.
56. When asked how he could be certain about this, Mr Joiner explained that his recollection was based on the fact that the first version of the procedure that he submitted to CASA required performance of the eddy current inspection using a manual probe. However, as Mr Joiner went on to explain, CASA later requested that the procedure be amended to stipulate performance of the inspection using a rotating probe. Mr Joiner pointed to the fact that whilst the EC procedure contains reference to a manual probe, the E procedure contains reference to a rotating probe. This fact, Mr Joiner explained, confirmed his stance that the E procedure was the one approved by CASA. In support of his position Mr Joiner also pointed to a contemporaneous invoice dated 12 September 2000¹⁸ for a rotating probe that he purchased in order to perform inspections using the E procedure.
57. The position of CASA is that the E procedure was never submitted for approval. According to CASA only the EC procedure was ever submitted by Mr Joiner for approval. The records produced by CASA¹⁹ during the course of the inquest establish that Issue 1 of the EC procedure was signed by Mr Joiner on 6 September 2000. A fax cover sheet indicates that it was then sent by fax from Mr Joiner (using Australian NDT letterhead) to Mr Bichard on 7 September 2000. The copy of Issue 1 of the EC procedure on the CASA file contains handwritten annotations on some of the pages and on the back of one of the pages. It is clear from a comparison between Issue 1 and Issue 2 of the EC procedure that the handwritten annotations on Issue 1 have been incorporated into Issue 2. For example, within section 9.0, titled “Inspection Results”, of Issue 1 is the handwritten annotation, “*and reinspect*” with a line drawn to a section of text. Examination of the same section 9.0 of Issue 2 reveals that the words “*and reinspect*” have been inserted at the relevant point in the text as identified by the handwritten annotation.
58. In support of its position regarding the EC procedure as being the only procedure that was ever approved CASA pointed to the evidence of Mr Pieter Van Dijk, the current CASA Continuing

¹⁸ Exhibit 4.

¹⁹ Exhibit 2.

Airworthiness Section Manager. Mr Van Dijk identified a number of anomalies with the E procedure, some of which are set out below:

- the procedure is not signed;
- the procedure contains paging errors, for example one page is numbered “Page 10 of 9”;
- the procedure contains inconsistencies with respect to the way in which it was to be performed such as notch sizes, characteristics, and expected responses; and
- the procedure incorrectly referred to “CASA Service Bulletin AD/PZL/5” in circumstances where no such document of this kind exists, and a CASA service bulletin and CASA airworthiness directive are two different and distinct documents.

59. Taking the above into account Mr Van Dijk stated “with a high degree of certainty that approval from CASA would not be forthcoming for an unsigned document containing such fundamental deficiencies”.²⁰

60. Apart from the identified anomalies CASA also pointed to the fact that both the September 2000 email and the September 2000 letter specifically referred to the EC procedure as the one approved by CASA. No mention was made of the E procedure in either the letter or the email.

61. However, counsel for Mr Joiner submitted that the identified anomalies with the E procedure could not persuasively resolve the question of which procedure was submitted and approved because the EC procedure itself also contained a number of anomalies. Some of these are set out below:

- the procedure is missing page 2;
- the fax timestamp on page 1 (11 September 2000 at 9:08am) is different to the timestamps on the subsequent pages (8 September 2000, between 3:50pm and 3:53pm); and
- Section 4.0 of the procedure directs a reader to Figure 2 in the procedure’s appendix which purportedly contains a reference standard for the eddy current procedure. However, Figure 2 contains no such reference standard but instead an exploded view of a centre wing section. It was noted by counsel for Mr Joiner that Figure 2 of the E procedure did, in fact, contain the appropriate reference standard.

62. Apart from the anomalies identified with the EC procedure, counsel for Mr Joiner also drew attention to the fact that following the accident CASA issued two amendments to the CASA AD. The purpose of the amendments was to mandate that NDT of the wing attachment joints for M18 Dromader aircraft could only be performed using MPI. The first amendment was issued on 15 November 2013 and the second was issued on 22 November 2013. It was identified that in both amendments there was a note referring to the fact that “the approval by CASA of [the E procedure] or other revision, as an alternative inspection procedure to use in lieu of the non-

²⁰ Exhibit 1, page 135-7.

destructive magnetic particle inspection procedure, has been revoked".²¹ Counsel for Mr Joiner therefore submitted that the reference in the notes to the E procedure meant that this was the procedure submitted to, and approved by, CASA.

63. One of the other anomalies which was noted with the E procedure was that it bore the Aviation NDT letterhead. This was curious given that the E procedure was dated 8 September 2000 but, as already noted above, Aviation NDT was not incorporated until 2007 when there was a transfer of ownership from Mr Joiner to Mr Tuck. However, this anomaly appeared to be explained in Mr Tuck's evidence. Mr Tuck said that when he took over ownership of the company in 2007 he altered an electronic version of the E procedure so that it bore the letterhead of Aviation NDT. Mr Tuck explained that he did so in order to make it clear that the document belonged to Aviation NDT.
64. I acknowledge that the documentary anomalies (such as missing page numbers and incorrect page numbering) with both the E procedure and the EC procedure appear to be difficult to rationally explain. Furthermore, neither Mr Bichard nor Mr Villiers were interviewed as part of the ATSB investigation and they also did not give evidence at inquest. However, what the available evidence does indicate is that the application and approval process was a fluid and dynamic one, with different versions (or issues) being submitted, amended, and then re-submitted. Because the amendments related to only some aspects of the procedure and not others, it is possible that in the approval process, aspects of both procedures were merged into one, thereby accounting for the identified anomalies.
65. It is also known, as the ATSB investigation found, that there was a lack of cross-referencing in files kept by CASA at the time.²² For example, information pertaining to the CASA AD was kept in a file separate to the file created for consideration of the procedure submitted by Mr Joiner in September 2000. The evidence also establishes (discussed further below) that different internal sections within CASA considered these related issues. These circumstances, and the circumstances described above concerning the application process, may possibly explain the reference in the two CASA AD amendments to the E procedure.
66. Neither Mr Joiner nor Mr Tuck were able to produce, or identify, any documentary record supporting the submission of the E procedure to CASA for approval. In contrast, only the EC procedure was found in the records kept by CASA and both the September 2000 email and the September 2000 letter refer specifically to it. I find that these contemporaneous records to be most persuasive (even allowing for the contemporaneous invoice produced by Mr Joiner) in coming to the conclusion that the procedure submitted by Aviation NDT to CASA for approval in September, and subsequently approved by CASA, was the EC procedure. This conclusion is also supported by the following matters:
 - (a) The E procedure indicated that it was devised to permit routine inspection of a type of document, namely a CASA Service Bulletin, which did not exist;
 - (b) The E procedure referred to the CASA AD which, as at the date of the E procedure, did not exist and would not be issued until 19 October 2000, some 41 days after the date of the E procedure;

²¹ Exhibit 1, page 290; Exhibit 3.

²² Exhibit 1, pages 187-188.

- (c) On 31 August 2004, Mr Joiner performed a NDT inspection on the main wing fittings of TZJ using a 100kHz probe. The E procedure required, as part of instrument calibration, the test frequency to be set to 300kHz whereas the EC procedure required the test frequency to be set to 100kHz. Mr Joiner's testing on 31 August 2004 was therefore consistent with the EC procedure;
 - (d) The EC procedure is signed and dated, unlike the E procedure; and
 - (e) The differences between Issue 1 and Issue 2 of the EC procedure are consistent with the handwritten notations recorded on Issue.
67. Counsel for Mr Joiner submits that Mr Joiner genuinely believed that the E procedure was the procedure that was approved by CASA Whilst Mr Joiner may have been genuine in his belief that is no substitute for the objective documentary evidence. That documentary evidence supports a finding, for the reasons already mentioned, that the EC procedure was the procedure approved by CASA.

(c) What was the effect of the approval?

68. In the September 2000 letter Mr Bichard indicated that the EC procedure had been submitted as an alternative to the method of inspection required in the PZL service bulletin, namely MPI. Mr Bichard told Mr Villiers that he had assessed the procedure and found that it would "*offer an equivalent, or superior, level of safety to the magnetic particle inspection*".²³ In summary, Mr Bichard recommended that the procedure be approved under regulation 2A(4) of the *Civil Aviation Regulations 1988* for use as approved (maintenance) data (**the 2A approval**).
69. Pursuant to regulation 2A(4) CASA may approve instructions (such as the EC procedure) relating to how maintenance on aircraft, aircraft components, or aircraft material is to be carried out. It should be noted that the instructions approved by CASA form only one part of the overall approved maintenance data for an aircraft, aircraft component, or aircraft material. Pursuant to regulation 2A(2) approved maintenance data also consists of, relevantly, directions made under an AD.²⁴ Instructions issued by aircraft manufacturers and designers of modifications also form part of the approved maintenance data.²⁵
70. In essence, the 2A approval meant that use of eddy current inspection had been approved by CASA in relation to M18 aircraft. However, that approval still needed to be taken into account together with the other requirements relating to approved maintenance data, in particular any applicable AD.
71. Another issue which the inquest considered was whether the approval communicated in the September 2000 letter amounted to a means of compliance other than that set out in the CASA AD. This issue arose because the evidence of Mr Donald Beal, Mr Bruce Beal, Mr Tuck and Mr Joiner is that in the period from 11 September 2000 to 8 August 2013 they were of the belief that the September 2000 letter authorised non-compliance with the CASA AD. They also all

²³ Exhibit 1, page 1706.

²⁴ Regulation 2A(2)(a)(ii), *Civil Aviation Regulations 1988*.

²⁵ Regulations 2A(2)(c), 2A(2)(d), *Civil Aviation Regulations 1988*.

stated in evidence that at no stage did they clarify with CASA whether the 2A approval authorised non-compliance with the CASA AD.

72. It was not in dispute at the inquest that the evidence of Mr Van Dijk²⁶, together with an examination of the applicable statutory regime, established that the 2A approval did not authorise non-compliance with the CASA AD. The only way to obtain approval for an alternative means of compliance (**AMOC**) with an AD was via a request, made in writing to CASA, pursuant to regulation 39.004 of the *Civil Aviation Safety Regulations 1998*.
73. The evidence establishes that the 2A approval also did not supersede the requirements of the subsequent CASA AD because, put simply, at the time the 2A approval was given the CASA AD had neither issued nor become effective. This meant that eddy current inspection for TZJ was only approved for the limited period between 11 September 2000 and 24 October 2000. From 25 October 2000 the CASA AD meant that inspection of the wing attachment joints could only be performed using MPI. For avoidance of doubt about the issue both Mr Donald Beal and Mr Tuck accepted in evidence that, having the issue brought to their attention after the accident, the CASA AD took precedence over the 2A approval.
74. Counsel for Mr Joiner submitted that it is inconceivable that CASA would have approved a procedure which permitted use of the eddy current method in circumstances where it was, concurrently, preparing to issue an AD which stipulated use of an entirely different inspection method. However in evidence Mr Van Dijk explained that, as a product of CASA's organisational structure, different sections within CASA were considering the issuing of the 2A approval on one hand, and the issuing of the CASA AD on the other. When asked whether, organisationally, this was a good idea, Mr Van Dijk indicated that he was unable to comment as he had no knowledge of how much interaction there had been within CASA between different sections, and between the people from these different sections. However Mr Van Dijk agreed that "cross-communication" would have been beneficial. When it was suggested to Mr Van Dijk that such an arrangement was not good corporate governance on the part of CASA and that it should have been better, Mr Van Dijk agreed that that was a "fair statement".
75. It seems to me that because of the internal organisational structure within CASA, it was quite conceivable for CASA to have given the 2A approval and then issued the airworthiness directive less than six weeks later. The possibility also exists that the 2A approval was given in anticipation of the CASA AD being issued and that, once approved, it may have been used later to support an application for an AMOC. Mr Van Dijk explained that on some occasions an approval pursuant to regulation 2A(4) may be relied upon by an applicant when making an application for an AMOC pursuant to regulation 39.004.²⁷
76. Taking all of the above into account, I therefore conclude that the eddy current inspection performed on TZJ on 8 August 2013 contradicted the mandatory requirements of the CASA AD. Due to a mistaken assumption about the nature and effect of the 2A approval, it was believed that the 2A approval authorised non-compliance with the CASA AD which mandated inspection of the wing attachment joints using MPI. That assumption and belief were both incorrect.

²⁶ Exhibit 1, page 135-5.

²⁷ Exhibit 1, page 135-6.

What occurred during the inspection of TZJ on 8 August 2013?

77. Mr Donald Beal was the relevant LAME for the inspection on 8 August 2013 (**the August 2013 inspection**). His role was to prepare the wing attachment joints for inspection. Mr Beal explained that he was given a clipboard by his son, Bruce, which contained, amongst other documents, a copy of the E procedure and a copy of the September 2000 letter. At the time he was given the clipboard Mr Beal said that he was also given a copy of the PZL service bulletin, which he had read several days earlier in preparation for the inspection.
78. Mr Beal explained that the wings were supported by a jack but remained in situ and that a cover panel was removed in order to access the wing attachment fittings. Mr Beal cleaned both the mandrel, and then the bore, with aviation turbine fuel and used a Scotch Brite pad to work around the bore. Mr Beal said that he used a torch to inspect the bore which he described as appearing “nice and bright” and he saw no evidence of corrosion or corrosion pitting.
79. However Mr Beal explained that because the wings were left in situ the visual inspection was limited. Accordingly, Mr Beal conceded that because he had been unable to visually inspect the complete bore surface area that corrosion may, in fact, have been present. Mr Beal also explained that he felt that there was a degree of ambiguity about what a visual inspection actually entailed. He said that he was of the impression that he only had to inspect the mandrel holes (that is, the bore) and not the surfaces of the lugs. He also explained that because the PZL service bulletin did not mandate removal of the wings in his view there was no need to remove them. When asked what the practical difficulty was with wing removal Mr Beal explained that fuel would have to be drained from the aircraft, electrical components would have to be disconnected and lifting equipment would be required to remove the wing. When Counsel Assisting summarised the position by saying that this effectively meant that it would be more costly and time-consuming to remove the wing, Mr Beal agreed.
80. Mr Tuck was the NDT technician who performed the inspection of the wing attachment fittings of TZJ using the eddy current method during the August 2013 inspection. He said that as part of the inspection process he was supplied with the E procedure, the September 2000 letter and the reference standard. Mr Tuck explained that the anomalies with the E procedure (such as the fact that it was not signed, the fact that the first page referred to the E procedure, but the footer of each subsequent page referred to the EC procedure, and the reference to the “CASA Service Bulletin”) did not cause him any concern; he simply assumed that they were typographical errors. Mr Tuck explained that in any event he had previously sighted a signed copy of the E procedure. However when asked about this signed version of the E procedure further in evidence, Mr Tuck confirmed that he had attempted to find it, but had been unable to locate a copy of it.
81. Mr Tuck indicated that he did not have a specific recollection of inspecting TZJ on 8 August 2013 but explained that his usual procedure was to calibrate his testing equipment, ensure the reference block was correct, remove the mandrels and clean them, perform the test on the bore, and then notify the LAME if there were any issues with the inspection results.
82. Mr Tuck said that he was certain that he tested TZJ on 8 August 2013. However Counsel Assisting took Mr Tuck to his the General Work Form (**the Form**) for all inspections conducted

by Mr Tuck on that day.²⁸ The Form recorded the registration numbers of eight aircraft that were to be inspected that day. TZJ is not recorded amongst the registration numbers. When shown the Form, Mr Tuck agreed that TZJ had not been recorded on it but again said that he was certain he had inspected it. By way of explanation Mr Tuck said that he was sure that he had recorded one registration incorrectly, but that he later corrected it on the NDT report which he eventually prepared following the inspection.²⁹ However, when asked by Counsel Assisting whether it was possible that TZJ may not have been inspected on the day, Mr Tuck accepted that this was a possibility.

83. Notwithstanding the absence of TZJ being recorded on the Form, other documentary evidence does in fact indicate that TZJ was inspected by Mr Tuck on 8 August 2013. Firstly, NDT report number R04653 indicates that TZJ was inspected. Both the order number (0511) and Form number (G3031) identified on the report are the same as the respective numbers recorded on the Form. Secondly, the text within the test results section of the report contains a reference to an aircraft with registration VH-TZT. Whilst this registration number is obviously different to the registration (VH-TZJ) recorded elsewhere on the form, this discrepancy is consistent with Mr Tuck's recollection that he had recorded one registration (TZT) incorrectly on the Form but had later corrected it (TZJ) on the actual NDT report. Thirdly, both the maintenance release³⁰ and airworthiness directive and special inspection sheet³¹ signed by Mr Beal referred to an inspection being performed on TZJ on 8 August 2013. In the case of the latter document the Form number (G3031) matched the number recorded by Mr Tuck.

Was the August 2013 inspection adequate?

84. The answer to this question is, simply put, no. As noted already, one obvious reason why this is so is because the use of the eddy current method during the inspection was unauthorised and did not comply with the mandatory requirements of the CASA AD.
85. However, there are also other matters which go to the issue of the adequacy of the August 2013 inspection. These matters relate to whether corrosion pitting and fatigue cracking were present at the time of the inspection.

(a) Was corrosion pitting present?

86. When the ATSB examined the surface of the fractured bore after the accident a number of corrosion pits measuring between 0.03mm and 0.16mm in depth were discovered. It was noted, firstly, that the bore surface was bright due to the absence of corrosion product (rust). This indicated that the surface of the bore had been cleaned, prior to examination by the ATSB, to remove any rust that might have been present and which normally covers the site of any corrosion. Secondly, it was noted that the bore surface included a number of fine circumferential marks. This was consistent with the application of an abrasive. What these two findings indicate is that the bore surface was cleaned in the manner explained by Mr Beal, but that the corrosion was either not detected or not removed in accordance with the PZL service bulletin.³²

²⁸ Exhibit 1, page 124.

²⁹ Exhibit 1, page 123.

³⁰ Exhibit 1, page 394.

³¹ Exhibit 1, page 622.

³² Exhibit 1, page 1669.

87. In these circumstances I conclude that corrosion pitting was present in the fractured bore at the time of the August 2013 inspection.

(b) Was fatigue cracking present?

88. The ATSB investigation found that the fatigue cracking in the fractured bore had reached a critical length of 10.4mm at the time of structural failure. At least 32 secondary micro cracks, of varying lengths up to 2.1mm, were also identified in the bore surface.³³ Using information provided by PZL, the ATSB calculated that it would take between 3,000 to 3,500 flight hours for an unmodified base aircraft, and without taking into account other factors that might affect crack growth (such as overweight operation), for a crack to grow to 11mm before failure.³⁴ At the time of the accident TZJ had only accumulated just over 126 flight hours since the August 2013 inspection.

89. The ATSB ultimately found that the fracture surface features were consistent with the cracking initiating and developing over an extended period. This led the ATSB to find that it was likely that the cracking initiated and had been developing for a period significantly longer than the time between the last inspection and the date of the accident.

90. On this basis I conclude that fatigue cracking, of undetermined length, was present at the time of the August 2013 inspection.

(c) Why was the corrosion pitting not removed and the fatigue cracking not detected?

91. Mr Donald Beal maintained in evidence that at the time he inspected the bore it appeared “quite bright and quite serviceable”. He also maintained that the Scotch Brite pad that he used was for the sole purpose of cleaning the bore and not for removal of corrosion. However, Mr Beal did concede that his visual inspection may have been compromised as a result of the wings remaining in situ, thereby limiting his inspection of the bore of the lug and all its surfaces. The evidence therefore establishes that corrosion pitting was present at the time of the accident, not because of an inadequate removal process, but rather because it was not detected at all during the August 2013 inspection.

92. In order to answer the question of why the fatigue cracking was not detected, an independent Level 3 NDT technician, Mr Malcolm Oakey, was asked to consider aspects of the August 2013 inspection and the events leading up to it. Mr Oakey prepared a report in which he relevantly explained:

(a) Magnetic particle testing for cracking in ferromagnetic materials is generally considered to be the preferred method due to its simple application process, its sensitivity to very small cracks, and the fact that it provides a visual indication on the surface of the part being tested that can be readily reviewed and photographed;³⁵

(b) Eddy current testing is generally considered less effective for small surface cracks than MPI because of the possibility that significant random noise may mask crack signals, the

³³ Exhibit 1, pages 216-217.

³⁴ Exhibit 1, page 173.

³⁵ Exhibit 1, page 23-13.

difficulty in sourcing or manufacturing reference samples to be used for equipment setup and calibration, and the limitation of probe design and effect coil diameters;³⁶

- (c) The reference sample used for August 2013 inspection was different in specifications to the reference sample referred to in the E procedure, leading to a reduction in the sensitivity of the test performed;³⁷
- (d) Using the instrument calibration specified in the E procedure along with the reference standard used on 8 August 2013 if the inspection were performed correctly it would be expected to detect bore surface cracks greater than 2.0mm in length;³⁸
- (e) However, most of the individual micro cracks up to 2.1mm in length found during the ATSB investigation would not be expected to be detected using the E procedure. In support of this conclusion, Mr Oakey conducted trials using similar equipment as that used on 8 August 2013 and applying the E procedure, and was not able to detect a known crack in a test part of 1.5mm in length.
- (f) A limitation of the E procedure is that it failed to clearly reference the required minimum signal to noise ratio while testing, which can lead to significant noise levels during the probe rotation masking true crack signals, resulting in missed cracking;³⁹
- (g) Even if the EC procedure had been used during the August 2013 inspection, this would not have affected any of the conclusions reached by Mr Oakey above.⁴⁰

93. In evidence Mr Tuck agreed that, in applying the E procedure, there was a failure to minimise the signal to noise ratio and also agreed that significant noise levels might mask a crack signal. Mr Tuck stated that he did not believe that the inspection of TZJ had been performed incorrectly, and based his belief on the fact that prior to the inspection he had performed the calibration correctly and had checked that the probe was also working correctly. When it was suggested by Counsel Assisting that there could have been an error with the probe or with the methodology employed which produced a false reading, Mr Tuck indicated that he was unable to comment. Similarly when Counsel Assisting suggested to Mr Tuck that (on the basis of Mr Oakey's report) if the eddy current inspection had been performed correctly it should have detected cracks greater than 2.0mm in length, Mr Tuck again indicated that he could not comment because he had not performed the trials that Mr Oakey had.

94. The contents of Mr Oakey's report were not challenged at the inquest. In essence, the report established that use of eddy current inspection in general was less effective than MPI, and that the E procedure in particular was compromised as its sensitivity for crack detection was reduced. Mr Tuck acknowledged this second issue. Assuming that the inspection was correctly performed, these two issues had the combined effect of resulting in a failure to detect the micro cracks which were present in the lug at the time of the August 2013 inspection.

³⁶ Exhibit 1, page 23-14.

³⁷ Exhibit 1, page 23-15.

³⁸ Ibid.

³⁹ Ibid.

⁴⁰ Exhibit 1, page 23-46.

95. In conclusion, the use of an inspection method contrary to the requirements of the CASA AD, the inability to conduct a thorough inspection with the wings removed, and the deficiencies of the E procedure all meant that the August 2013 inspection was inadequate.

Should any recommendations be made?

96. Section 82 of the Act allows a coroner to make recommendations in relation to any matter connected with a person's death. Section 82 provides that such recommendations may be made if the coroner considers them to be necessary or desirable. Issues of public health and safety can be, and often are, the subject of recommendations.
97. At the conclusion of the inquest Counsel Assisting and counsel for some of the interested parties made submissions regarding a number of issues that might be the subject of a recommendation. I will consider each issue in turn.

(a) Removal of aircraft wings during inspection

98. The ATSB found that wing removal was necessary to provide adequate access for effective visual and magnetic particle inspections of the wing attachment fittings. However the PZL service bulletin specified that MPI could be performed without the need for wing removal. In order to address this issue the ATSB sought a response from PZL. That response was provided in September 2015 to the effect that PZL would issue a service letter stating that if a person carrying out an inspection in accordance with the PZL service bulletin was unsure whether a bore could be correctly inspected for possible cracking then the wing should be disassembled.⁴¹ That service letter has since been issued by PZL.
99. In evidence Mr Ballard explained that the hesitation on the part of PZL appeared to be based on the possibility that technology may be developed in the future to allow for the possibility of performing effective and reliable MPI without the need for wing removal. However, as both Mr Tuck and Mr Joiner stated in evidence they were not aware of any such technology having been developed, or in the process of being developed.
100. It seems to me that the most recent service letter issued by PZL leaves the question of wing removal at the discretion of LAMEs and NDT technicians performing the inspection in circumstances where the evidence at the inquest and the findings of the ATSB investigation are that wing removal allows for more effective MPI and visual inspection. This is in circumstances where Mr Donald Beal gave evidence that there was some ambiguity on his part as to what a visual inspection actually entails, that is what parts of a lug need to be inspected. For avoidance of doubt, and to remove the variability that may be associated with the exercise of individual discretion, my view is that the matter ought to be resolved definitively by CASA. Any airworthiness inspection regime should be sufficiently robust, clear and precise. For these reasons I consider it to be necessary to make an appropriate recommendation to CASA. Counsel for CASA took no issue with the making of such a recommendation.

⁴¹ Exhibit 1, pages 195-196.

(b) Service life factoring of aircraft

101. During the course of the inquest some attention was given to the concept of aircraft service life factoring. This is a means of more accurately calculating the amount of fatigue damage an aircraft accrues over its time in service. It is done by relying not only on actual flight hours, but by also taking into account factors, such the speed at which an aircraft operates and the weight of loads that the aircraft carries (overweight operations), which contribute to fatigue damage and effectively age an aircraft more quickly. To account for the higher rate of fatigue, a service life factor is applied to the flight time. Multiplying the actual flight time by the service life factor results in a factored flight time. This is then used to determine the aircraft's time in service for retirement and maintenance scheduling purposes.
102. PZL originally determined the service life limitation for the M18 based on a maximum take-off weight of 4,700kg. There were no records to determine whether TZJ had operated at weights above 4,700kg prior to being imported into Australia in 2004 and, if it had, whether service life factors had been correctly applied. The ATSB investigation revealed that at various times in TZJ's history in Australia, its time in service was either not factored correctly, or not factored at all. This was due to a number of reasons such as retrospective service life factoring being applied for the period between 2009 and 2013 as a result of a CASA direction. However, this refactoring did not account for operations in Australia at higher weights between 2004 and 2009, nor any higher weight flights that might have occurred before the aircraft arrived in Australia in 2004. The ATSB calculated that had the service life factors been applied in accordance with TZJ's maintenance documentation for all the time it was operated in excess of 4700kg then TZJ may have accrued up to 12,190 factored hours, thereby exceeding its adjusted service life limitation of 10,000 hours.
103. In general maintenance releases, such as those completed by Mr Beal on behalf of TZJ following the August 2013 inspection, allow for LAMEs to record an aircraft's total time in service as at the date of issue of the release. By their very nature, when service life factors are applied, they will produce calculations of factored flight time that will be greater than actual flight time. It is important that factored flight time be recorded in an aircraft's logbook in order to accurately assess when an aircraft may be approaching the end of its service life. It seems to me that it is equally important that such information be accurately recorded on an aircraft's maintenance release. This is particularly so given that, in the case of TZJ, the CASA AD required inspection intervals to be measured according to an aircraft's factored flight time. For these reasons I consider it to be necessary to make an appropriate recommendation to CASA.
104. Counsel for CASA raised no issue with this proposed recommendation other than to submit that the concern on behalf of CASA would be to not unwittingly introduce potential risk factors. Appropriate consideration would also need to be given to the scope of any direction given by CASA and the type of aircraft that might be covered by such a direction.

(c) Pre-2009 service life factoring

105. Related to the general issue of service life factoring is a specific issue concerning M18 Dromader aircraft. This issue arose because of a direction given by CASA in 2013 (referred to above) which required M18 operators to retrospectively apply service life factoring to aircraft for the period between 2009 and 2013. This direction was given in circumstances where the ATSB found that

three M18 operators had flown nine aircraft (including TZJ) in overweight operations for more than 90% of the time between 1999 and 2008.⁴²

106. In evidence Mr Bruce Beal explained when the CASA direction was given he and David performed the necessary service life factor calculations, recording the factored hours in the relevant logbooks for each aircraft. Mr Beal agreed with counsel for Mrs Black that if the direction from CASA had been to apply the factoring for the period prior to 2009 that he would have complied with such a direction and that he possessed the necessary information in order to do so.
107. In evidence Mr Van Dijk agreed that CASA gave the direction knowing that TZJ had performed overweight operations during the period from 2004 to 2008. Counsel for Mrs Black that CASA had omitted from its direction information which it knew and which meant the factoring was misleading. Mr Van Dijk explained that he was not aware of the justification behind the direction and he speculated that there would be some engineering justification leading to the direction applying only to a specified period of time, that is, from 2009 to 2013. Counsel for Mrs Black suggested that whatever the justification might have been, it could not have been effective. Mr Van Dijk responded by stating that he could not comment without knowing the reasoning process behind the direction from CASA.
108. By virtue of the above counsel for Mrs Black submitted that a recommendation should be made that CASA consider issuing a further direction requiring service life factoring to be applied to M18 aircraft prior to 2009. Given the concessions made by Mr Van Dijk the submission appears to be logically sound. However, the difficulty in converting that logic into a recommendation is that the issue was, in my view, insufficiently canvassed at the inquest. Mr Van Dijk was not involved in the making of the direction and, as he explained, he was unaware of the engineering justification behind it. In order to make the recommendation sought by counsel for Mrs Black, appropriate and careful consideration would need to be given to the specifics of the engineering justification process.

(d) Auditing conducted by CASA airworthiness inspectors

109. By virtue of the misunderstanding associated with the applicability of the 2A approval and the September 2000 letter, it became apparent during the course of the inquest that both Australian NDT and Aviation NDT had performed inspections between September 2000 and August 2013 contrary to the requirements of the CASA AD. This in turn raised the question of how such a situation could have occurred given that CASA airworthiness inspectors (**AWI**) routinely performed inspections of aircraft maintenance organisations and, in the specific case Australian NDT and Aviation NDT, the title of their NDT inspection reports made it plain that the eddy current method of inspection had been used for M18 aircraft. These matters were posed to Mr Van Dijk.
110. In response Mr Van Dijk explained that he had obtained a briefing from the current CASA inspector responsible for the auditing process. When asked whether the NDT report prepared for TZJ following the August 2013 inspection might have raised the index of suspicion of an AWI because it was clearly titled “Eddy Current Inspection Report”, Mr Van Dijk indicated that such a report probably “would not have raised any eyebrows at the time”. When asked why that was

⁴² Exhibit 1, page 162.

the case Mr Van Dijk explained that an AWI in general has little understanding of NDT and would not have necessarily understood what such a report might have meant in the context of an overall audit.

111. On this basis counsel for Mrs Black submitted that a recommendation should be made for CASA to consider the quality of training provided to AWIs and the manner in which audits are conducted. Again I agree that, on the available evidence, the submission is logically sound but again the difficulty with making such a recommendation is that the evidence was not sufficiently explored in detail. This is because, as explained above, the evidence given by Mr Van Dijk was, effectively, second and third hand hearsay. The information that Mr Van Dijk was able to gather was only in extremely broad terms. For example, his evidence did not even establish how frequently audits are performed by AWIs. On Mr Van Dijk's evidence such audits might possibly have been performed every one or two years, without being any more precise. There was even less evidence about the qualifications of AWIs and what is involved in the audit process other than to, as Mr van Dijk put it, "provide regulatory oversight to give an idea of the status and health of maintenance organisations". None of this is meant to be critical of Mr Van Dijk's evidence in any way; it simply emphasises the fact that the evidence given by Mr Van Dijk was essentially simply a summary of a general conversation he had had with another person within CASA. It seems to me that collection of appropriate evidence from primary sources, and source material, and consideration of these matters in detail would be required before any recommendation might possibly be made.

(d) Continuing education for licensed aircraft maintenance engineers

112. Counsel for Mr Donald Beal and Mr Bruce Beal submitted that a recommendation should be made to CASA to consider implementing some system of continuing education for LAMEs. Counsel made the submission on the basis that, as he put it, LAME's were operating in a "cauldron of confusion" due to the complexities associated with the aircraft maintenance industry. With respect to counsel, that type of broad submission was unsupported by the available evidence.
113. In my view there was considerably less evidence at inquest about this issue than the issues concerning pre-2009 service life factoring and field audits conducted by CASA. In effect the evidence amounted to Mr Bruce Beal stating that he found the documents relating to the September 2000 letter, the CASA AD, and the E procedure "confusing". My own view is that the terms of the September letter and the CASA AD were in unambiguous terms and that it is part of the fundamental license requirements for a LAME to have a sound understanding of the differences between a 2A approval and an AMOC.
114. However, counsel for CASA indicated in submissions that CASA would consider whether there is scope to examine the possibility of some continuing education system for LAMEs. On that basis, my view is that a recommendation about this issue is not necessary.

Findings

115. Before turning to the findings that I am required to make, I would like to acknowledge and thank Mr Adam Casselden SC, Counsel Assisting and Ms Mena Katawazi, instructing solicitor from the Office of the General Counsel, for their valuable assistance and significant contributions both before, and during, the inquest. I would also like to thank, and express my appreciation for the

efforts of, the various investigators involved in this matter: Mr Paul Ballard, Mr Graham Drummond and their team from the ATSB; as well the police officer-in-charge, Detective Senior Constable David Neil.

116. The findings I make under section 81(1) of the Act are:

Identity

The person who died was David Black.

Date of death

David died on 24 October 2013.

Place of death

David died in an area of the Budawang National Park, about 37km west of Ulladulla, New South Wales.

Cause of death

The cause of David's death was multiple injuries.

Manner of death

David suffered multiple injuries when the aircraft that he was piloting impacted terrain following the in-flight separation of the aircraft's left wing. The wing separation was caused by corrosion pitting and fatigue cracking in the lower left wing attachment fitting leading to the fracture and critical failure of the attachment lug.

Recommendations

117. For the reasons outlined above I make the following recommendations pursuant to section 82 of the Act:

118. ***To the Civil Aviation Safety Authority:***

- (a) I recommend that consideration be given to the issuing of an airworthiness directive pursuant to regulation 39.001 of the *Civil Aviation Safety Regulations 1998* requiring that visual inspections and magnetic particle inspections of the wing attachment joints of M18 Dromader aircraft, and its variants, be performed with the outboard wings removed.
- (b) I recommend that consideration be given to the issuing of an airworthiness directive pursuant to regulation 39.001 of the *Civil Aviation Safety Regulations 1998*, or a direction given under regulation 43 of the *Civil Aviation Regulations 1988*, that aircraft factored time in service should be recorded on all maintenance releases in order to accurately determine an aircraft's time in service for service life limitation considerations and maintenance scheduling purposes.

Epilogue

119. On behalf of the coronial team I would like to offer my sincere and respectful condolences to David's family, in particular his wife, Julie; his children, Oliver, Sophie, and Adelaide; and his parents, Sarah and Andrew.

120. At the end of the inquest Julie described David as being someone who had amazing attention to detail and who was a stickler for the rules. I hope that the inquest has examined the circumstances surrounding David's death with equal and appropriate attentiveness and that the recommendations which have been made improve current regulations and requirements that relate to aircraft safety. Such improvements would, no doubt, be an important and meaningful outcome to emerge from the tragedy of David's death.

121. I close this inquest.

Magistrate Derek Lee
Deputy State Coroner
13 March 2017
NSW State Coroner's Court, Glebe