Australian Government
Australian Transport Safety Bureau

Runway excursion involving a Fairchild Metro 23, VH-UUB

Portland, Victoria | 20 February 2014

Investigation

ATSB Transport Safety Report
Aviation Occurrence Investigation
AO-2014-028
Final – 22 March 2016

Cover photo: Courtesy of airline operator

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

Publishing information

Published by: Australian Transport Safety Bureau
Postal address: PO Box 967, Civic Square ACT 2608
Office: 62 Northbourne Avenue Canberra, Australian Capital Territory 2601
Telephone: 1800 020 616, from overseas +61 2 6257 4150 (24 hours)
Accident and incident notification: 1800 011 034 (24 hours)
Facsimile: 02 6247 3117, from overseas +61 2 6247 3117
Email: atsbinfo@atsb.gov.au
Internet: www.atsb.gov.au

Addendum

Page	Change	Date

Safety summary

What happened

On 20 February 2014 at 1425 EDT, a Fairchild Industries Metro 23 aircraft, registered VH-UUB, was being operated on a charter flight from Avalon to Portland, Victoria with 10 passengers and two crew on board. Shortly after touch-down the torque link on the left, main landing gear (MLG) failed. The aircraft veered left as a result, and came to rest beside the runway. There were no injuries as a result of the occurrence.

UUB after veering off runway

Source: airline operator

What the ATSB found

The runway excursion resulted from failure of the lower torque link attachment lug on the left main landing gear's yoke. This allowed the wheels to rotate through 90° with respect to the direction of aircraft travel and skid, producing a large braking effect on the left side. The flight crew were unable to counteract this and it resulted in the aircraft veering to the left and off the runway.

The failure of the lug on the yoke resulted from pre-existing cracks that had progressively grown until the part had insufficient strength to support normal landing loads. The cracks initiated principally from areas of pitting corrosion in the lug's bore and were propagated by cyclic stresses imposed during operation.

The ATSB identified a safety issue whereby the maintenance and inspection program for the aircraft's landing gear did not adequately provide for the detection of corrosion and cracking in the yoke lug bore.

What has been done as a result

The Civil Aviation Safety Authority (CASA) has released Airworthiness Bulletin AWB 32-023 to alert all Fairchild Swearingen Metro and Merlin operators of the need for detailed inspection of the internal bore of the landing gear torque link lugs for any signs of corrosion or wear outside of the manufacturer's specified limits and to take appropriate action per the aircraft's structural repair manual, where necessary.

In addition, the aircraft's Type Certificate Holder has drafted service bulletins 226-32-083, 227-32-065, CC7-32-030 titled "inspection of Main Landing Yoke for Corrosion and/or Damage" that will significantly increase the effectiveness of maintenance inspections for the affected parts.

Safety message

This occurrence highlights the importance of developing and conducting appropriately detailed maintenance inspections on susceptible parts and assemblies.

Contents

The occurrence

On 20 February 2014, a Fairchild Industries SA227-DC 'Metro 23' aircraft, registered VH-UUB, had been flown from Avalon to Portland, Victoria on a charter flight. On board were two flight crew and 10 passengers. A normal approach was conducted and the aircraft touched down at 1425 EDT[1]. During the landing roll, the flight crew noted the aircraft began veering to the left. The flight crew attempted to counteract the movement, using rudder inputs, reverse thrust on the engines and the right brake, but the aircraft subsequently departed the runway at a speed of 75 to 80 knots and began to slide sideways. The left main landing gear (MLG) dug into the ground and the nose of the aircraft swung sharply to the left as it came to a stop. The flight crew shut the aircraft down and disembarked the passengers when it was safe to do so. There were no reported injuries as a result of the occurrence.

Subsequent inspection of the aircraft found that the torque link[2] had detached from a fractured lug on the lower section of the left MLG (arrowed in Figure 1b), allowing the wheel assembly to rotate through 90° w.r.t. the direction of aircraft travel. This resulted in skidding wheels, producing a significant braking effect on the left main gear and causing the aircraft to veer to left and depart the runway (Figure 2).

Figure 1: Damage to the left MLG

Source: Airline operator

1 Eastern Daylight Savings Time (EDT) is Universal Co-ordinated Time (UTC) + 11hours.

2 The torque or scissor link, is a hinged link between the upper and lower sections of the landing gear that allows the suspension system to articulate while preventing the lower section (yoke) from rotating.

Figure 2: Damage to runway as a result of contact with the left main landing gear following failure

Source: Airline operator

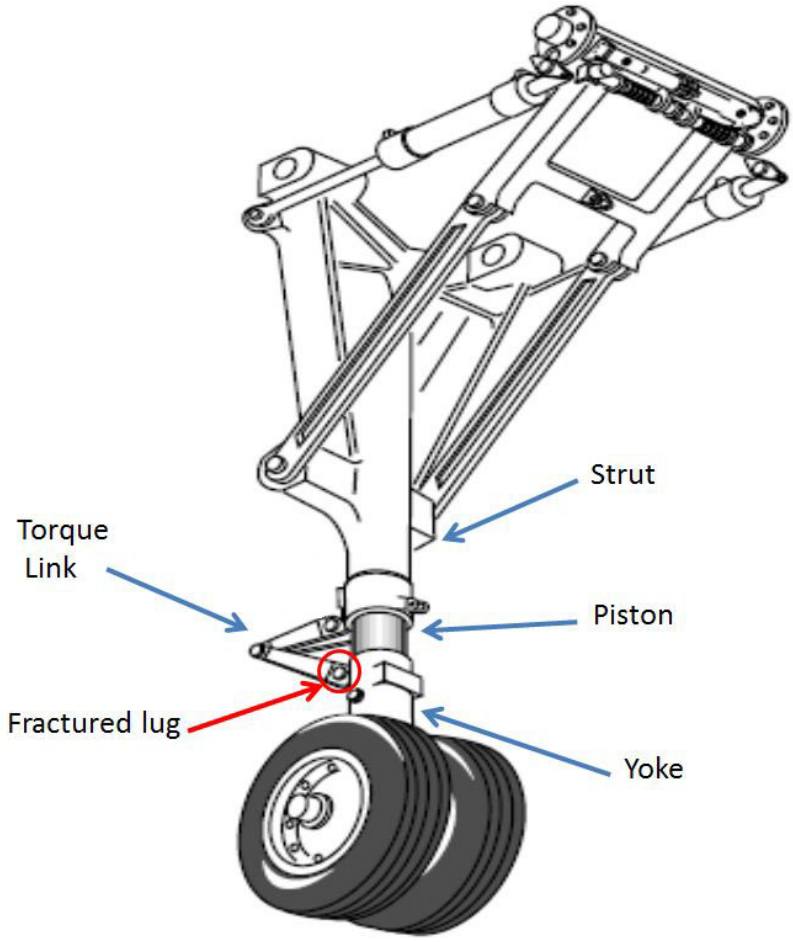
Context

Main landing gear description

The main landing gear assembly is composed of a telescoping upper cylinder (strut), a piston assembly and, at the lower end, the yoke (Figure 3). A torque link assembly connects at lugs on the strut and the yoke, allowing compression of the assembly while preventing rotation of the yoke. In this occurrence, the lug on the yoke had fractured.

Yokes in the MLGs of earlier SA227 models were manufactured by Ozone Industries as part number (P/N) OAS5453005-5[3]. In later models, manufacture was by another landing gear vendor, Klune Industries, and started with the fabrication of the 27-series part numbers. The fractured yoke from VH-UUB was identified as P/N 27-51505-005, manufactured by Klune Industries.

Figure 3: MLG assembly highlighting key components



Source: M7 Aerospace SA227 Maintenance Manual (Modified by ATSB)

[3] CASA AD/SWSA226/74 Amdt 3.

Recorded information

The ATSB downloaded and analysed data from the aircraft's Flight Data and Cockpit Voice Recorders (FDR & CVR, respectively). The data confirmed that following touchdown, the aircraft began veering to the left. Approximately 8 seconds later, the aircraft departed the runway. In addition, the following points were noted:

- The vertical speed prior to landing was that of a normal approach.
- Vertical decelerations recorded during the touch-down were not excessive.
- The airspeed at touch-down was consistent with prior flights.
- The aircraft was correctly configured for landing.

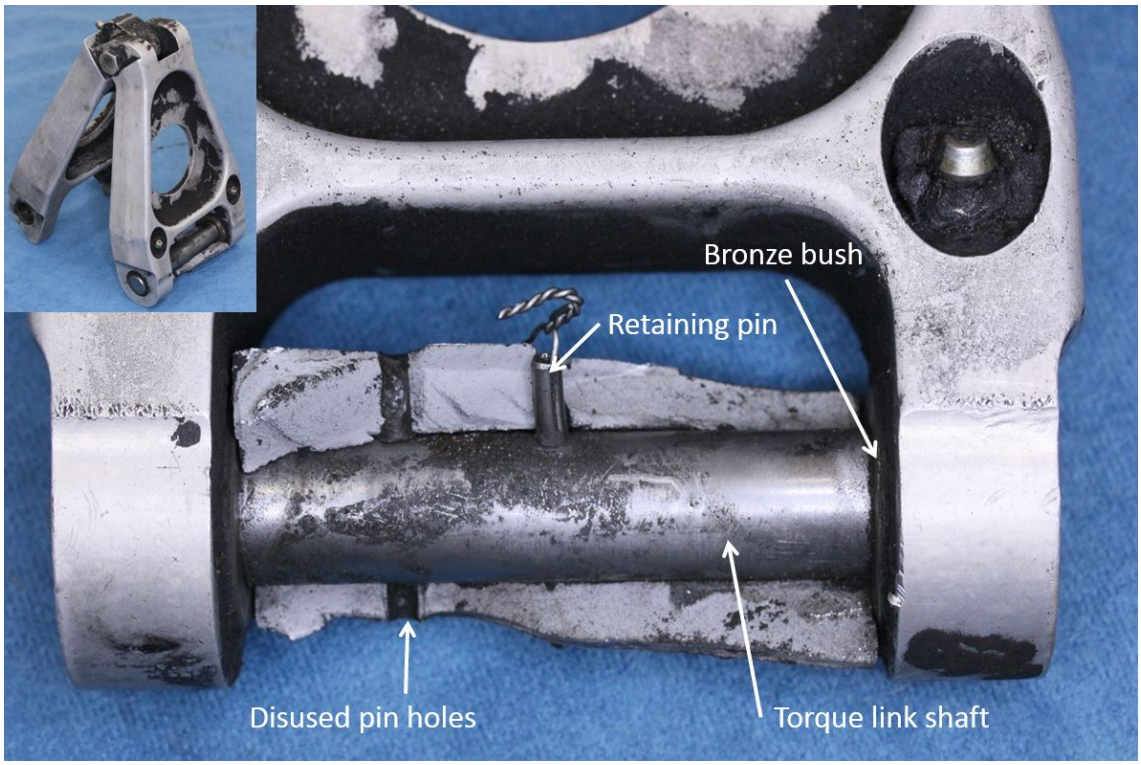
Component Examination

Lug Fracture

The aluminium torque link and yoke were assembled via a steel torque link shaft (TLS) that mated with bronze bushes in the lower link. It was secured with a single, stainless steel retaining (spring) pin with stainless steel lockwire in its bore (Figure 4).

The fractured yoke contained four disused retaining pin holes (two each top and bottom) as a result of compliance with a service bulletin (SB) for installing a replacement TLS (CC7-32-012), released in 2002. The SB required drilling of a new pin hole in the lug to secure the replacement TLS and filling of the redundant holes with sealant. As-examined, the disused holes in the fractured yoke were not sealed, but instead contained black corrosion/wear product. However, traces of sealant around some of the holes suggested that they had probably been filled at the time of service bulletin compliance.

Figure 4: Lower torquelink attachment assembly with fractured lug segment in-situ

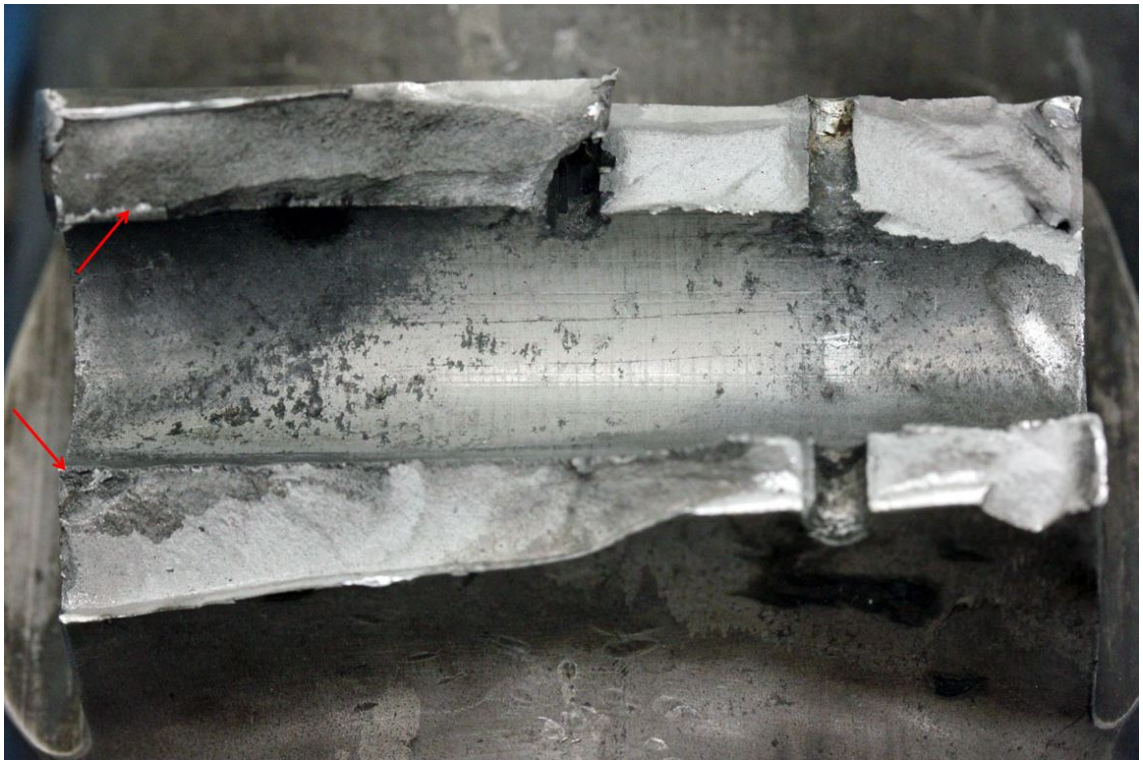


Source: ATSB

Significant corrosion pitting was evident in the bore of the lug and on the lug flanks, with concentrations around the four disused, spring pin holes (Figure 5). Fatigue crack progression (beach) marks were identified on the lug fracture surfaces with the crack origins located at areas of significant corrosion pitting and wear in the bore. The fatigue cracking progressed across most of the lug cross section before the remaining portion fractured by ductile overstress. The overstress areas were largely defined by a narrow region on the outside radius of the lug (furthest from the bore).

Detailed examination of the corrosion pits adjacent to the fracture surface found evidence of corrosion product as well as a series of crack progression marks radiating outwards from the edge of the corroded areas.

Figure 5: Yoke lug exhibiting corrosion pitting, wear in the bore and fatigue crack progression on the fracture surfaces (main crack origins arrowed)



Source: ATSB

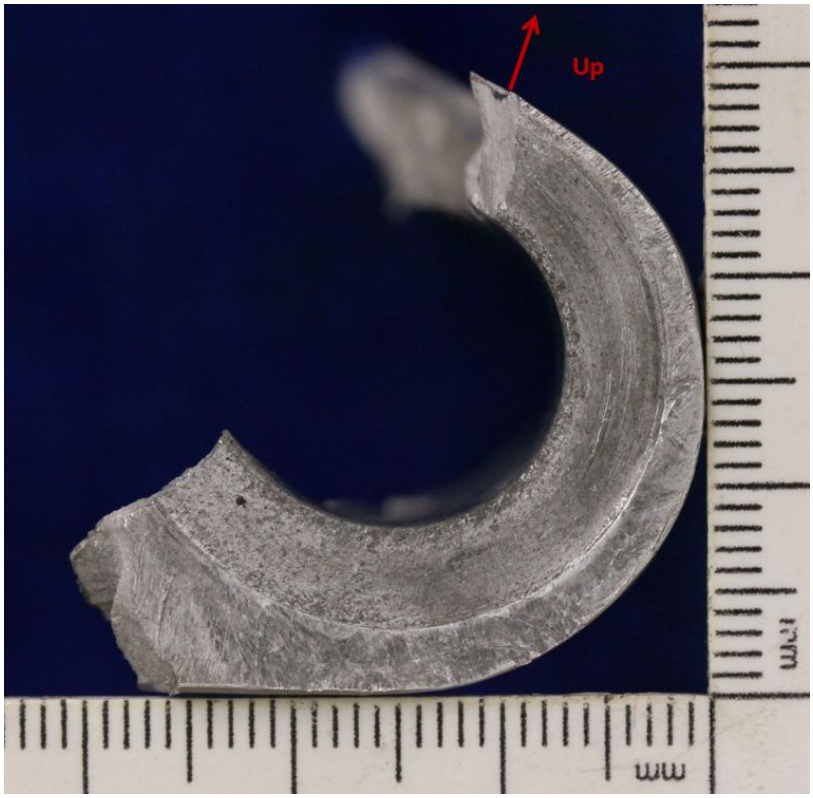
Lug dimensions

The bronze bushes installed in the lower torque link had worn against the yoke's lug flanks during normal operation such that, in the areas of greatest wear, the width of the lug was now 66.03mm (2.6") which was 0.26mm (0.01"), below the minimum dimension of 2.61" (66.294mm) specified in the structural repair manual (Figure 6).

Material properties

The material properties were correct for the specified 7075-T73 aluminium alloy. Electrical resistivity testing showed that a majority of the chromic acid anodised coating, applied to the component during manufacture, had worn away, increasing the component's susceptibility to corrosion and wear, particularly in an aqueous environment of metals dissimilar to aluminium.

Figure 6: Flank of the fractured yoke lug showing surface wear from mating bush



Source: ATSB

Yoke maintenance requirements

The Fairchild MLG yokes were maintained on condition and were not subject to any maximum service life restrictions. At the time of the occurrence, the SA227 Phase Inspection Manual (SA227 CC/DC Commuter Category, Rev 19, Sept 28, 2012) included requirements for inspection of the aircraft structure and components. The definitions section of the manual stated that;

> *A routine inspection – Visual inspection not requiring removal of access panels or fairings.*
> *A detailed inspection – Detailed inspection requiring removal of access panels, doors, fairings, covers, upholstery and components for inspection.*

The aircraft was maintained using a 6-phase inspection program with an interval of 900 hours; this included a detailed inspection of the main landing gear at a phase 3 inspection (450 hours) and a routine inspection at a phase 6 inspection (900 hours).

The phase inspection manual also included a section which included a list of requirements for the routine and detailed inspections. The detailed inspection included the requirement to inspect struts for damage, evidence of leakage, condition and security, and to inspect scissors and bushings for wear, condition and security. The manufacturer advised that in order to perform these inspections, the shaft attaching the scissor links to the yoke lug should be removed and the condition of the components checked, as well as the wear limits.

The most recent detailed (Phase 3) inspection was 436.5 hours prior to the occurrence, and a routine (Phase 6) inspection 37.3 hours prior to the occurrence. The operator's inspection procedures followed the guidelines in the inspection manual and there was no record of the components being disassembled at either inspection. The operator advised that they performed a torque link freeplay inspection at the detailed inspection and if excessive freeplay was evident, then the components would be disassembled for further inspection.

In August and September 1995, Fairchild issued two service bulletins to cover six of the earlier SA227 models equipped with Ozone MLG & NLG (Nose Landing Gear) yokes. This was due to

failures initiated by stress corrosion cracking and corrosion fatigue. In those occurrences, the failure origin was at the forging die parting (flash) line in the upper yoke area, where the piston was shrink-fitted. Both the Federal Aviation Administration and the Civil Aviation Safety Authority issued airworthiness directives a month later.

Other occurrences

On 10 June 2007, an SA227-DC, registered VH-HPE, sustained a left MLG yoke lug failure during post-landing taxiing at Tennant Creek Aerodrome. The ATSB did not investigate that occurrence, however a report provided to the ATSB indicated that the fracture similarly related to fatigue crack progression precipitated by wear, corrosion pitting and stress corrosion cracking in the yoke lug bore.

The Civil Aviation Safety Authority (CASA) were aware of four Australian-registered, SA227 MLG torque link lug failures, as well as cracking of a yoke lug, found during daily inspection, on a Canadian-registered aircraft.

The manufacturer advised they were aware of two cracked yoke lugs, which were found by the same Canadian operator in 2012. A failure analysis report for one of the failures showed similar cracking to that identified on UUB. The report stated that the failure occurred as a result of cracking that had initiated at multiple corrosion pits on the inner surface of the lug. In this case however, the cracking had propagated to the external surface, which allowed it to be identified during a daily maintenance inspection. The same Canadian operator also experienced a third failure in December 2015, which was identified by the flight crew after landing.

Safety analysis

Occurrence

The runway excursion involving Fairchild Industries Metro 23 VH-UUB at Portland, Victoria, on 20 February 2014, was the result of the failure of a lug on yoke of the wheel assembly on the left main landing gear (MLG) during the landing roll. The failure of the lug disconnected the torque link between the upper MLG strut and the lower wheel assembly; this allowed the wheel assembly to rotate through 90° with respect to the direction of travel. This effectively resulted in a large braking force on the left side of the aircraft. The flight crew were unable to counteract that asymmetric braking force and as a result, the aircraft veered off the runway

Failure of the MLG yoke lug

The yoke lug fractured as a result of a fatigue cracking mechanism with crack initiation points located in the bore of the lug at areas of significant wear and corrosion pitting. The fatigue crack progressed through most of the lug cross section before final fracture during the occurrence landing.

Corrosion pits act as stress concentrators and significantly reduce both the fatigue crack initiation life of the component as well as the crack initiation threshold stresses. The corrosion, wear and cracking had likely been present in the lug bore for a significant period of time prior to failure occurring. Early indications of corrosion and cracking on the lug bore would not have been visible during the inspections prescribed in the inspection manual, without first disassembling the affected parts. Neither the detailed nor routine inspections explicitly required an inspection of the lug bore, although the manual contained a general definition of a detailed inspection that required components to be disassembled for examination. The list of required inspection items also implied that some disassembly would be required to adequately inspect various components. The operator indicated that while no disassembly was performed, a torque link freeplay inspection was performed which would have led to further examinations if anomalies, such as excessive movement, were found.

There were several factors that influenced corrosion of the yoke lug bore. Sealing of the disused pin holes in this occurrence was not adequate as the sealant had either broken down over time or otherwise disbonded and come loose during service, providing additional entrance routes for moisture or other corrosives. Another entrance route was associated with wear on the yoke lug flanks where significant pitting was identified. Wear on the flanks and in the bore of the lug was sufficient to remove the protective anodic coating, which increased the susceptibility of the parts to corrosion. With corrosion pitting being a precursor to the fatigue failure of the component, improvement of corrosion protection in the affected areas would further reduce the likelihood of this type of occurrence.

Findings

From the evidence available, the following findings are made with respect to the runway excursion involving a Fairchild Metro 23 aeroplane, registered VH-UUB, which occurred at Portland, Victoria on 20 February 2014. These findings should not be read as apportioning blame or liability to any particular organisation or individual.

Safety issues, or system problems, are highlighted in bold to emphasise their importance. A safety issue is an event or condition that increases safety risk and (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 operating environment at a specific point in time.

Contributing factors

- The runway excursion occurred as a result of fracture of the torque-link attachment lug on the aircraft's left main landing gear yoke, which allowed those wheels to deviate from the normal direction of travel and cause asymmetrical braking forces that could not be countered by the flight crew.
- The torque link-to-yoke attachment lug fractured under normal operational loads as a result of the initiation and propagation of fatigue cracks originating at areas of excessive wear and corrosion pitting on the lug bore.
- **The maintenance program for the aircraft's landing gear did not adequately provide for the detection of corrosion and cracking in the yoke lug bore. [Safety issue]**

Safety issues and actions

The safety issues identified during this investigation are listed in the Findings and Safety issues and 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.

Depending on the level of risk of the safety issue, the extent of corrective action taken by the relevant organisation, or the desirability of directing a broad safety message to the aviation industry, the ATSB may issue safety recommendations or safety advisory notices as part of the final report.

Where relevant, safety issues and actions will be updated on the ATSB website as information comes to hand. The initial public version of these safety issues and actions are in PDF on the ATSB website.

Inadequate inspection procedures

Number:	AO-2014-028-SI-01
Issue owner:	M7 Aerospace (Elbit Systems of America)
Operation affected:	Aviation: Maintenance
Who it affects:	All owners and operators of Fairchild Swearingen Metro and Merlin aircraft

Safety issue description:

The maintenance program for the aircraft's landing gear did not adequately provide for the detection of corrosion and cracking in the yoke lug bore.

Pro-active safety actions taken by the Civil Aviation Safety Authority

Action number: AO-2014-028-NSA-002

The Civil Aviation Safety Authority (CASA) released Airworthiness Bulletin AWB 32-023 to alert all Fairchild Swearingen Metro and Merlin operators of the need for detailed inspection of the internal bore of the landing gear torque link lugs for any signs of corrosion or wear outside of the manufacturer's specified limits and to take appropriate action per the aircraft's structural repair manual, where necessary.

ATSB comment/action in response

This action appropriately highlights the need for conducting detailed inspections in the affected areas of the landing gear yoke and shaft.

Pro-active safety actions taken by M7 Aerospace

Action number: AO-2014-028-NSA-003

M7 Aerospace has drafted service bulletins SB 226-32-083, 227-32-065, CC7-32-030 entitled "Inspection of Main Landing Gear Yoke for Corrosion and/or Damage" for all operators of SA226- and 227 aeroplanes with M7/Fairchild Main Landing Gear Yoke and Torque Link Shaft installed. The SB will require disassembly of the components and detailed visual inspection, liquid penetrant inspection, magnetic particle inspection and high-frequency eddy current inspections for cracks or corrosion on and inside the torque link lug and shaft of the MLG yoke.

ATSB comment/action in response

This action requires appropriately detailed inspections to be conducted in the affected areas of the landing gear yoke and shaft and will adequately address the safety issue (once released).

Pro-active safety actions taken by Sharp Airlines

Action number: AO-2014-028-NSA-007

The operator indicated that they had inspected all in-service landing gear assemblies for damage, and had replaced the lower yokes on all MLG fitted to their Metro 23s. Both the operator's current Metro IIIs had new gears installed in 2012 and 2013, as part of an upgrade to the aircraft. The operator also advised that they were in the process of writing a new gear maintenance program for all their landing gears to increase vigilance in areas of the torque links, which will include removal of the pins at each Phase 3 inspection/overhaul.

ATSB comment/action in response

This action has resulted in more detailed inspections of the affected areas of the landing gear yoke and shaft and in combination with the actions taken by other parties has adequately addressed the safety issue.

Current status of the safety issue

Issue status: Adequately addressed

Justification: The actions taken by both CASA and M7 Aerospace should facilitate the early identification of corrosion and cracking in the yoke lug bore.

General details

Occurrence details

Date and time:	20 February 2014 – 14:45ESuT	
Occurrence category:	Serious incident	
Primary occurrence type:	Technical failure	
Location:	Portland, Victoria	
	Latitude: 38° 19.1' S	Longitude: 141° 28.3' E

Aircraft details

Manufacturer and model:	Fairchild Industries SA227-DC 'Metro 23'	
Year of manufacture:	1996	
Registration:	VH-UUB	
Operator:	Sharp Airlines	
Serial number:	DC-894B	
Type of operation:	Passenger charter	
Persons on board:	Crew – 2	Passengers – 10
Injuries:	Crew – nil	Passengers – nil
Damage:	Substantial	

Sources and submissions

Sources of information

Sources of information used during the investigation included:

- the aircraft's type certificate holder
- the aircraft operator
- the Civil Aviation Safety Authority
- the operating flight crew
- the aircraft's flight data recorders.

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 operator, the aircraft maintenance provider, M7 Aerospace and CASA.

Submissions were received from the operator, M7 Aerospace and CASA. The submissions were reviewed and where considered appropriate, the text of the report was amended accordingly.

Australian Transport Safety Bureau

The Australian Transport Safety Bureau (ATSB) is an independent Commonwealth Government statutory agency. The ATSB 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 operations involving the travelling public.

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 factors related to the transport safety matter being investigated.

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 it appropriate. There is no requirement for a formal response to an advisory notice, although the ATSB will publish any response it receives.

Australian Transport Safety Bureau

Enquiries 1800 020 616
Notifications 1800 011 034
REPCON 1800 011 034
Web www.atsb. gov.au
Twitter @ATSBinfo
Email atsbinfo@atsb.gov.au
Facebook atsbgovau

Investigation

ATSB Transport Safety Report
Aviation Occurrence Investigation

Runway excursion involving a Fairchild Metro 23, VH-UUB
Portland, Victoria; 20 February 2014

AO-2014-028
Final – 22 March 2016