Report 00-006

Fairchild SA227-AC Metro III

ZK-RCA

undercarriage failure and subsequent wheels-up landing

Gisborne and Hamilton Aerodromes

15 June 2000

Abstract

On Thursday 15 June 2000 at around 1400, ZK-RCA, a Metro III, landed on runway 14 at Gisborne Aerodrome at which time its left undercarriage drag braces both failed, causing the left undercarriage to collapse aft. A go-around was carried out and the aircraft flown to Hamilton Aerodrome for a wheels-up landing. The 2 pilots on board the aircraft were not injured.

The undercarriage failure resulted from a fatigue crack that had developed and grown to a critical length in the left undercarriage outboard lower drag brace. The fatigue crack started in a recess machined to accommodate a grease fitting, near the attachment point to the undercarriage leg. The crack was not detectable during normal maintenance procedures. The inboard drag brace failed in overload when the outboard drag brace failed.

Safety issues identified included the need for improved design and inspection requirements for Metro aircraft undercarriage drag braces. The manufacturer and the United States and New Zealand safety authorities addressed the safety issues. No safety recommendations were required.

The Transport Accident Investigation Commission is an independent Crown entity established to determine the circumstances and causes of accidents and incidents with a view to avoiding similar occurrences in the future. Accordingly it is inappropriate that reports should be used to assign fault or blame or determine liability, since neither the investigation nor the reporting process has been undertaken for that purpose.

The Commission may make recommendations to improve transport safety. The cost of implementing any recommendation must always be balanced against its benefits. Such analysis is a matter for the regulator and the industry.

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ZK-RCA Metro III
After the wheels-up landing

Contents

Figures

List of Abbreviations

CAA	Civil Aviation Authority (New Zealand)
cm	Centimetre (s)
FAA	Federal Aviation Authority (United States)
FDR	flight data recorder
g	vertical acceleration (gravity)
kg	kilogram(s)
km	kilometre(s)
m	metre(s)
mm	millimetre(s)
MPa	megapascal(s)
NTSB	National Transportation Safety Board (United States)
UTC	Co-ordinated universal time
VHF	very high frequency

Data Summary

Aircraft type, serial number and registration:	Fairchild SA227-AC Metro III, AC637 ZK-RCA
Number and type of engines:	2 Garrett TPE331-11U-611G
Year of manufacture:	1986
Date and time of occurrence:	15 June 2000, 1400[1]
Location:	Gisborne Aerodrome latitude: 38º 39.9´ south longitude: 177º 58.7´ east
Type of flight:	crew training
Persons on board:	crew: 2 passengers: none
Injuries:	crew: nil
Nature of damage:	substantial to the aircraft
Captain's licence:	Airline Transport Pilot Licence (Aeroplane)
Captain's age:	35
Captain's total flying experience:	5287 hours (2842 hours on type)
Investigator-in-charge:	K A Mathews

[1] Times in this report are New Zealand standard time (UTC + 12 hours).

1. Factual Information

1.1 History of the flight

1.1.1 On Thursday 15 June 2000 at 1328, ZK-RCA, a Fairchild SA227-AC Metro III, operated by Eagle Airways Limited (the operator) took off from Gisborne Aerodrome for a planned one-hour crew-training flight. A check and training captain (the captain) and a pilot undergoing command training, who was the pilot flying, were on board the aircraft.

1.1.2 The flight included emergency procedure exercises with simulated engine failures, circuits and landings using runway 14. The first circuit was normal using both engines. The second circuit was flown with the left engine power lever retarded to simulate a left engine failure shortly after take-off. On short final approach a single-engine go-around was commenced from the decision height and the aircraft recircuited with the left engine simulated as inoperative.

1.1.3 The third circuit was flown at an altitude lower than normal. A moderate wind from the south-west created a right crosswind for the landing. The pilots said the approach was normal until about a height of 50 feet before landing when the aircraft descent rate increased. They said the landing was somewhat firmer than normal and firmer than they expected. Although the aircraft landed straight it began to veer to the left and the pilot under training was unable to maintain directional control. The captain ordered a go-around.

1.1.4 A flying instructor who was standing by his aircraft parked near the control tower witnessed the approach and landing. He had an unobstructed view of the left side of ZK-RCA. He said the approach appeared normal until about the last 50 feet when the aircraft established a high sink rate and landed very hard. At touchdown he saw the left undercarriage collapse rearwards to about 40 degrees past its normal down position and the aircraft veer left. He thought the left propeller was going to strike the runway. He ran up to the control tower and told the controller what he had seen. He also telephoned the operator.

1.1.5 When the aircraft became airborne the crew selected the undercarriage up but the left undercarriage red in-transit indicator light remained on. After the aircraft climbed to 1500 feet above mean sea level the captain reselected the undercarriage down. The nose and right undercarriage position indicator lights displayed normal green (down) indications but the left undercarriage red in-transit indicator light remained on.

1.1.6 After the aircraft became airborne the aerodrome controller told the crew that the left undercarriage was not down correctly but was hanging at about 45 degrees. The crew, unsure whether the undercarriage was inclined forward or trailing, loaded the aircraft with positive "g" (vertical acceleration) in an attempt to force the undercarriage into the down locked position. The red indicator light remained on. The pilot under training then flew the aircraft at low level past the control tower and the controller confirmed the undercarriage was trailing at about 45 degrees aft of its normal down position.

1.1.7 The pilot under training flew the aircraft to the east and to a higher altitude where the crew considered their options. The captain spoke to the company's Gisborne base manager and company personnel at Hamilton, advising them of the situation. The captain elected to fly ZK-RCA to Hamilton Aerodrome where the company's headquarters and engineering base were located. Hamilton Aerodrome was an international aerodrome with a higher category of emergency services and a longer runway than Gisborne Aerodrome.

1.1.8 The flight to Hamilton was flown with the undercarriage selected up but at a speed below the undercarriage extended speed limitation of 173 knots. The captain spoke with the operator's engineering personnel and the Metro fleet captain. Following the fleet captain's advice the crew swapped seats to occupy their more familiar positions, with the captain in the left seat and the pilot under training in the right seat.

1.1.9 The captain completed 2 low approaches and overshoots at Hamilton Aerodrome for engineering and flying personnel to view the undercarriage in the down selected and up selected positions. This was carried out to analyse the possible failure and to assist the captain to decide what action he should take.

1.1.10 In the retracted position the left undercarriage wheels protruded below the engine nacelle some 45 degrees below the normal horizontal up position. The captain decided to land the aircraft with the undercarriage selected up, in accordance with the manufacturer's recommendation. He orbited over the aerodrome burning off fuel to the minimum, leaving about 10 minutes of fuel to complete a landing, or carry out a go-around for a second approach if necessary.

1.1.11 In the meantime the emergency rescue services and the operator put together a plan to attend the aircraft as it landed and to recover it from the runway. The crash fire service sprayed fire retardant foam along the runway to reduce the potential for fire.

1.1.12 The captain flew a stabilised approach to runway 18. On short final some 50 feet before touchdown he directed the second pilot to pull both the red engine stop and feather knobs. This action cut the fuel supply to both engines and feathered the propellers. The second pilot also closed the fuel shut-off valves and hydraulic shut-off valves. The captain selected the batteries off.

1.1.13 ZK-RCA touched down straight and slid some distance before it slewed to the right side of the runway and onto the grass where it turned through about 170 degrees and came to rest. About 1700 m of runway were used during the landing. The pilots evacuated the aircraft immediately through the emergency exit over the right wing, having already informed the emergency services of their plan.

1.1.14 Once the pilots cleared the aircraft the emergency fire service sprayed fire retardant under the aircraft around likely hot spots. This action had been predetermined and was taken to eliminate the potential for fire to erupt in the event any fuel lines or fuel tanks had ruptured. The fire retardant was biodegradable and non-corrosive. No fire occurred.

1.2 Injuries to persons

1.2.1 No one was injured during the landing.

1.3 Damage to aircraft

1.3.1 The left propeller blade tips had struck the runway on landing at Gisborne Aerodrome after the left undercarriage collapsed, resulting in significant damage to each of the 4 propeller blade tips. The pilots were unaware of the propeller strike and did not detect any in-flight engine or propeller vibration. Both engine propellers were feathered before the landing at Hamilton Aerodrome but they were destroyed from bending and abrasion during the landing.

1.3.2 The engines were removed for overhaul following the accident. There was substantial abrasion damage to the trailing edge of the right flap and rear fuselage. The right undercarriage doors on the bottom of the right engine nacelle were abraded and bent. The left undercarriage doors below the left engine nacelle and left flap were undamaged where the partially extended left undercarriage absorbed the landing forces. Impact damage to the fairing aft of the left undercarriage occurred when the undercarriage collapsed rearwards. The right engine nacelle showed evidence of some torsional and compression buckling. The left engine nacelle showed no evidence of any torsional or compression buckling.

1.3.3 Both lower left undercarriage drag braces failed near their respective attachment points on each side of the undercarriage leg, through a recess machined to accommodate a grease fitting. The fracture surfaces on the matching end of each drag brace were abraded from scraping on the runways. The broken end piece of the outboard drag brace remained attached to the undercarriage leg. The inboard broken end piece was later found at Gisborne Aerodrome. The 2 undercarriage hydraulic actuator arms for the left undercarriage had bent around the undercarriage leg attachment points when the undercarriage leg collapsed rearwards. The arms were bent upwards about 20 degrees approximately 5 cm from the end of each arm and prevented the left undercarriage from retracting fully into the left engine nacelle. Some structural damage occurred near the left undercarriage drag brace upper attachment area. The left undercarriage down lock bellcrank bearing shattered when the undercarriage collapsed rearwards.

1.4 Pilot information

1.4.1 The captain was a male aged 35. He was a qualified B and D category flying instructor and check and training captain for the Metro aircraft. He held an Airline Transport Pilot Licence (Aeroplane) and a Class 1 Medical Certificate valid until 11 July 2000 with no restrictions.

1.4.2 At the time of the accident the captain had amassed 5287.05 flying hours, including 2841.55 hours on Metro aircraft.

1.4.3 The pilot undergoing command training was a female aged 36. She held a Commercial Pilot Licence (Aeroplane), B category flying instructor rating and a Class 1 Medical Certificate valid until 17 November 2000.

1.4.4 At the time of the accident the pilot undergoing training had amassed 4605.15 flying hours, including 3120.50 hours on Metros.

1.5 Aircraft information

1.5.1 ZK-RCA was a Fairchild SA227-AC Metro III, serial number AC637, twin-engine all-metal aircraft, constructed in the United States in 1986. The aircraft was fitted with Garrett TPE331-11U-611G gas turbine engines.

1.5.2 The aircraft had been issued with a non-terminating Certificate of Airworthiness in the standard category. The aircraft was routinely used for regular public transport flights and had seating normally for 19 passengers and 2 pilots. The aircraft had an approved maximum take-off weight of 6578 kg and a landing weight of 6350 kg.

1.5.3 The aircraft weight and balance were later calculated to be within limits. The landing weight at Gisborne Aerodrome when the undercarriage collapsed was calculated to be 5050 kg. No cargo or baggage was onboard the aircraft, except for the normal aircraft equipment and some small personal items belonging to the pilots. The pilots had placed 100 kg of ballast in the aft cargo compartment to keep the centre of gravity within limits.

1.5.4 The aircraft records indicated that ZK-RCA had been maintained in accordance with its approved schedule and that it had accumulated 24 797.3 hours total time-in-service and 36 925 landing cycles at the time of the undercarriage failure. The last inspection was completed on 8 June 2000 at 24 750.8 hours. The next check was due on 22 June or at 24 817.4 hours, whichever came first.

1.5.5 The aircraft was equipped with a hydraulically actuated, fully retractable, tricycle undercarriage with an emergency extension system. The main undercarriage legs retracted forward and upward into their respective engine nacelle housings. Each main undercarriage leg extended down and aft to a vertical position and was locked in place by a matched pair of drag braces. The drag braces, one inboard and one outboard, attached to either side of each leg about half way down its length (see Figure 1).

1.5.6 The drag braces were an on-condition[2] item. The manufacturer only required condition and security checks to be carried out. There was no requirement to use an approved crack detection method to check the drag braces for cracking.

1.6 Meteorological information

1.6.1 The weather at Gisborne Aerodrome included a few clouds with visibility over 40 km. The wind was up to 15 knots from the south-west.

1.6.2 The weather at Hamilton Aerodrome was clear and calm with 40 km visibility.

1.7 Communications

1.7.1 The aircraft was equipped with very high frequency (VHF) transceivers for normal air-to-air and air-to-ground communications.

1.8 Aerodrome information

1.8.1 Gisborne Aerodrome had an air traffic control system in operation at the time of the accident. The aerodrome had bitumen runways 14 and 32 with available accelerate-stop distances of 1310 m. The runways were 45 m wide.

1.8.2 An inspection of runway 14 at Gisborne after the undercarriage failure showed evidence that ZK-RCA touched down near the runway centreline, approximately 124 m in from the threshold. There were multiple propeller strikes a short distance after the touchdown point.

1.8.3 Hamilton International Aerodrome had bitumen runways 18 and 36. The available accelerate-stop distance for runway 18 was 1960 m. The runway was 45 m wide.

1.9 Flight recorders

1.9.1 The aircraft was equipped with a Fairchild A100A cockpit voice recorder and Fairchild F800 flight data recorder (FDR). Both recorders were recovered undamaged from the aircraft.

1.9.2 The Commission took the FDR to the Australian Transportation Safety Bureau in Canberra for data recovery. The recorded data was successfully recovered and included elapsed time, indicated airspeed, pressure altitude, magnetic heading, vertical acceleration, and VHF transceiver keying.

1.9.3 Two significant positive “g” excursions were indicated. The first indicated excursion of 2.1 g occurred on landing at Gisborne and correlates with the undercarriage failure. The second indicated excursion to 2.5 g occurred during flight and correlates with the crew using positive “g” in an attempt to lock the undercarriage down.

[2] A preventative process that allows deterioration of components by monitoring those components for their continued compliance with a required standard.

Figure 1
Metro undercarriage leg showing inboard and outboard lower drag braces

1.10 Tests and research

1.10.1 After the undercarriage failure the operator inspected the undercarriages on its fleet of 5 remaining Metro aircraft and crack checked the lower drag braces using dye penetrant. The crack checking was performed around the recesses machined to accommodate grease fittings. All the 5 other Metro III aircraft were found to have cracks in the lower drag brace machined recess area; 2 aircraft had cracked drag braces on both main undercarriage legs. The 5 aircraft ranged from 19 763 flying hours and 31 035 landing cycles to 32 370 flying hours and 40 765 landing cycles.

1.10.2 The Commission took the 2 end pieces from the failed lower drag braces from ZK-RCA, and one cracked but intact lower drag brace from Metro ZK-OAA, to the Materials Performance Technologies Limited laboratory for examination and analysis.

Examination results

1.10.3 The results from the examination of the failed components are summarised as follows:

- the inboard lower drag brace failure was typical of overload; no evidence of fatigue was seen
- in the failed outboard lower drag brace a fatigue crack had started and propagated from the edge of the machined bolting face at the top of the grease fitting hole (see Figure 2)
- the fatigue crack was multi-origined (this was indicative of a relatively high stress failure)
- the fatigue crack surface was slightly polished and darker in colour than the remainder of the fracture surface
- the fatigue crack surface was relatively rough (this was indicative of a low cycle fatigue failure rather than a high cycle fatigue failure)
- the fatigue crack had started around the change in section. The crack had propagated at the surface over a length of about 10 mm and to a maximum depth of 8 mm, from the outer corner where the crack met the side of the brace
- away from the area of fatigue, the fracture was typical of overload
- the edge of the machined area had been formed with a square-edged cutter. There had been no attempt to radius the corner during manufacture
- some corrosion was present in the outboard drag brace end bushing.

1.10.4 The intact drag brace from ZK-OAA (see Figure 3) was mounted in a tensile testing machine and loaded between pins placed in the end attachment holes. At a load of 13 525 kg one of the pins holding the drag brace fractured. Examination of the drag brace after the test revealed that the crack had become visible to the naked eye. The drag brace was reloaded in the testing machine between high tensile bolts. The lower end of the drag brace failed at a load of 20 000 kg. Based on the cross-sectional width of the bulk of the brace this was estimated to equate to a tensile strength of 290 MPa (megapascals).

1.10.5 The lower end of the drag brace failed in a near identical manner to the inboard drag brace from ZK-RCA. Examination of the fracture revealed that:

- a small fatigue crack had been present at the end of the edge of the machined region in a similar location to the fatigue crack seen in the outboard drag brace from ZK-RCA, except that it ran towards the left rather than the right of the fracture
- the fatigue crack was about 0.8 mm deep and ran around the change in section for about 4 mm (see Figure 4).

Microstructure and hardness

1.10.6 Examination of metallographic sections revealed that the samples from ZK-RCA had a fine-grained structure with an even distribution of coarse precipitates.

1.10.7 The material used by the manufacturer for the production of Metro drag braces was aluminium alloy 2014 T6 forging.

1.10.8 Vickers hardness tests were carried out on the 3 metallurgical samples in accordance with British Standard 427. The average results were as follows:

ZK-RCA outboard brace	159 Hv (10 kg)
ZK-RCA inboard brace	173 Hv (10 kg)
ZK-OAA	163 Hv (10 kg)

1.10.9 Alloy 2014 in the T6 condition has typical properties of:

Hardness	159 Hv
Tensile strength	483 MPa
Yield strength	414 MPa
Elongation	14%

1.10.10 The measured maximum stress in the drag brace from ZK-OAA of 290 MPa was probably not a true representation of its tensile strength because of the grease fitting hole and the small pre-existing crack.

Electron microscopy

1.10.11 A ground section of the sample from ZK-RCA and the sample from ZK-OAA were analysed in a scanning electron microscope using an energy dispersive X-ray analysis system. The results obtained in 3 locations on each sample are shown in Table 1. This type of analysis is semi-quantitative and the variations in the results on each sample are typical of the variations in results expected (refer to 2.9 for analysis of this table).

Table 1. Elemental analysis by weight (%)

Sample	**Mg**	**Si**	**Cr**	**Fe**	**Cu**	**Mn**	**Al**
ZK-RCA a	0.5	0.7	0	0.7	4.8	na	93.4
ZK-RCA b	0.1	0.2	0.1	0.6	6.2	na	92.8
ZK-RCA c	0.7	0.8	0	0.4	5.4	na	92.8
ZK-OAA a	0.9	0.8	0.2	0.8	5.1	na	92.2
ZK-OAA b	0.9	0.8	0.2	0.5	5.6	na	92.0
ZK-OAA c	0.7	0.3	0.2	0.5	5.5	na	92.9
AA2014 [standard]	0.2-0.8	0.5-1.2	<0.1	<0.7	3.9-5.0	0.4-1.2	rest

1.10.12 The fatigue portion of the fracture of the sample from ZK-RCA was examined in a scanning electron microscope. The fracture had a number of origins. Where the micro cracks intersected a small step was produced (castellations). Fatigue striations were present in areas away from the origins. Near the origins, the surface was corroded/fretted. The spacing of the striations was measured. The striation spacing increased in size from 1.8 microns at a distance of 1.3 mm from an origin to 3 microns at a distance of 3.6 mm from an origin. In the area examined, the fatigue crack was 3.6 mm deep at this position, which was about 5 mm from the outer corner of the fracture. No striations were readily visible nearer than 1.3 mm from the origins.

1.10.13 The fatigue portion of the fracture of the sample from ZK-OAA was examined in a scanning electron microscope. This revealed the fracture was multi-origined, and that striations were present. The fatigue striation spacing was measured and found to be 1.3 microns at a distance 0.466 mm from the nearest origin. At the end of the fatigue arc, 0.595 mm from the nearest origin, the striation spacing was 1.9 microns.

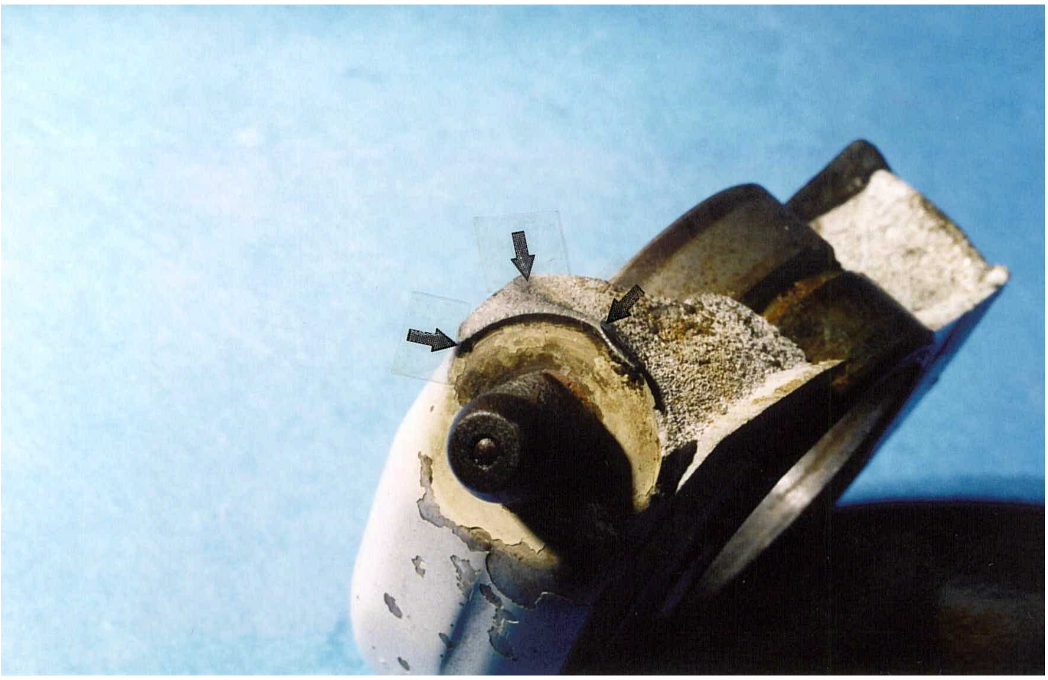

Figure 2
The broken outboard drag brace end piece from ZK-RCA showing the fatigue crack (arrowed)

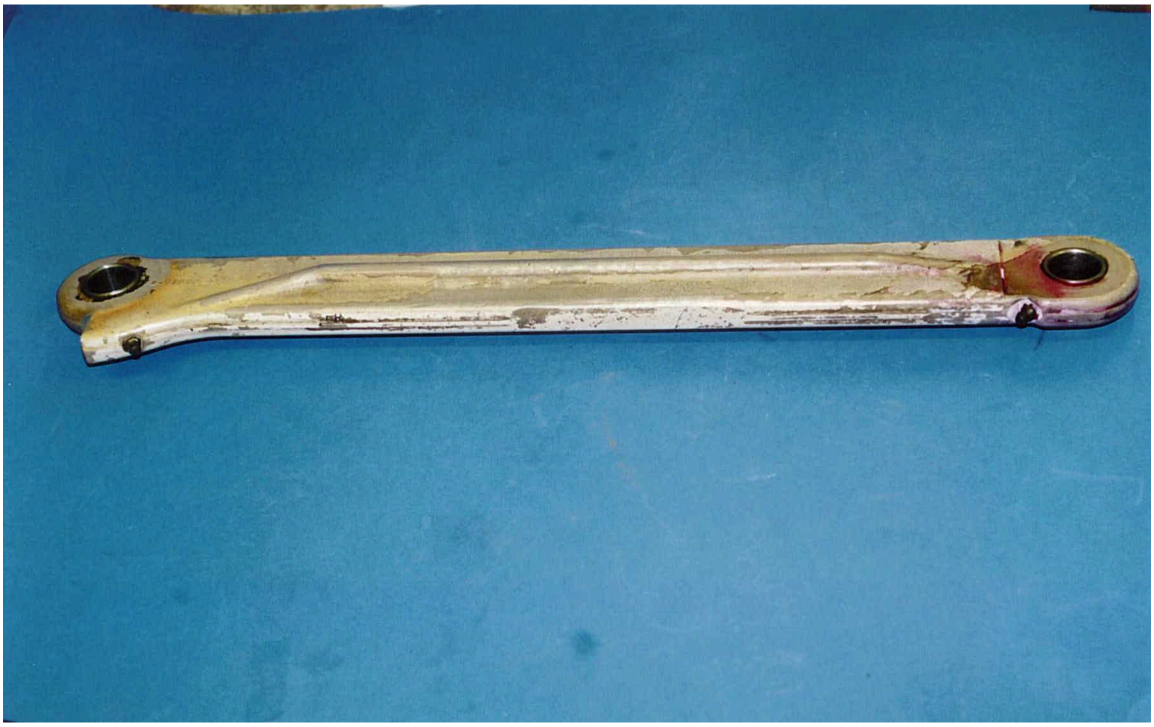

Figure 3
The complete but cracked lower drag brace from ZK-OAA

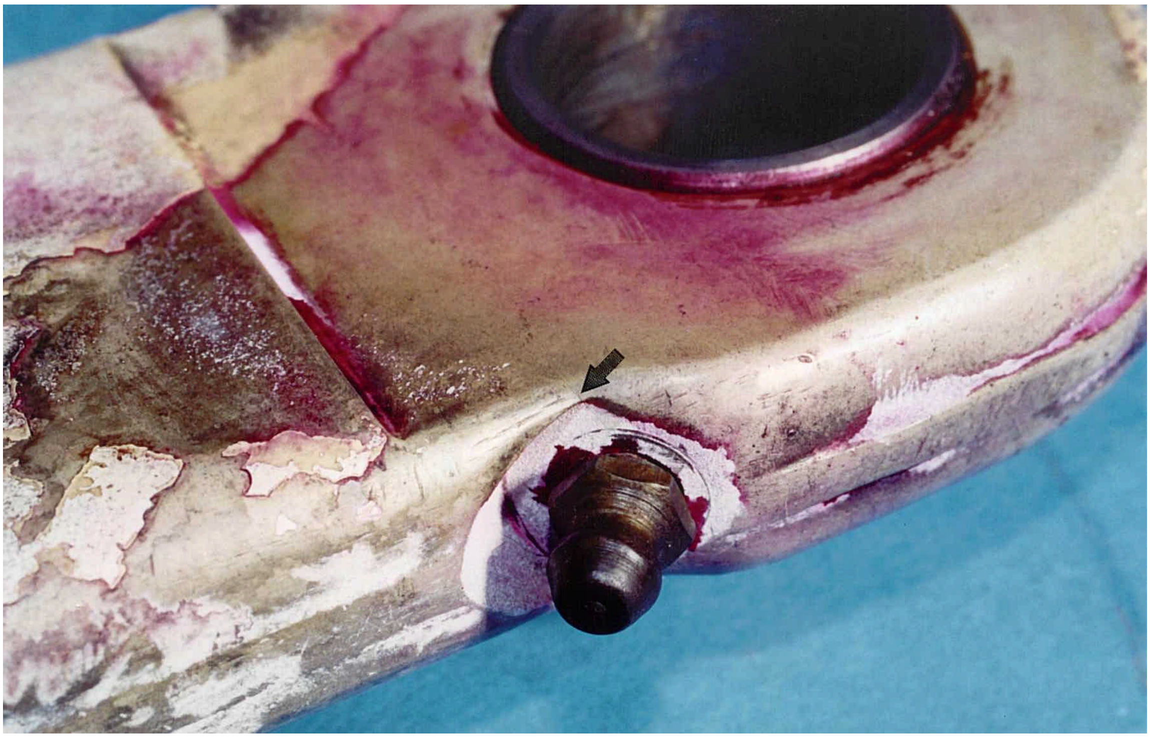

Figure 4
The fatigue crack in the lower drag brace from ZK-OAA (arrowed)

1.11 Additional information

1.11.1 Following the undercarriage failure the operator informed the other New Zealand Metro operators. The Commission advised the Civil Aviation Authority (CAA) of the cracking and a CAA officer inspected the failed drag braces at the Materials Performance Technologies laboratory.

1.11.2 Three days after the accident the aircraft manufacturer's representative arrived in New Zealand to inspect ZK-RCA and some of the operator's other Metro aircraft.

1.11.3 Another New Zealand operator discovered 2 of its fleet of 6 Metro III aircraft had cracked drag braces in the machined recesses similar to ZK-RCA and the operator's other Metro aircraft. One aircraft had recorded 14 087 flying hours and 23 861 landing cycles. The other aircraft had 18 665 flying hours and 29 808 landing cycles.

1.11.4 The other New Zealand operator had replaced the drag braces on a Metro with used but serviceable components supplied by the manufacturer. The drag braces were checked for cracks before installation and subsequently in accordance with the Service Bulletin and Airworthiness Directive. After 126 flying hours and 203 landing cycles the right inboard drag brace had developed a 3 mm long crack running around the outer edge of the grease fitting recess.

1.11.5 The Australian Civil Aviation Safety Authority advised on 9 August 2000 that it was not aware of any reports of cracked drag braces from its Metro operators. The authority said it was continuing to follow up on the problem and found it interesting there had been no reports given the extent of the problem in New Zealand.

1.11.6 The National Transportation Safety Board (NTSB) advised on 10 August 2000 that the Federal Aviation Authority (FAA) was not aware of any reports of cracked or failed drag braces from its Metro operators. The NTSB said it and the FAA believed there likely were cracked drag braces in the United States Metro fleet. An FAA Airworthiness Directive was processed based on the New Zealand problem, which incorporated a reporting provision to determine exactly how big the problem was.

2. Analysis

2.1 The operator routinely used ZK-RCA for regular public transport flights, at times carrying 19 passengers. The aircraft had flown 4 public transport flights on the day of the accident, before it took off from Gisborne Aerodrome on the crew training flight. The aircraft records showed ZK-RCA had been maintained appropriately to conduct those flights.

2.2 During the command training flight with one engine simulated as inoperative, the aircraft landed firmly. However, since the aircraft was empty and significantly lighter than its maximum allowable landing weight the undercarriage was subject to considerably less impact force than it would have been at the maximum aircraft landing weight.

2.3 There was no evidence around the left engine nacelle that the aircraft had been subject to a heavy landing. The torsional and compression buckling around the right engine nacelle, which is typically seen following a heavy landing, would have occurred when the aircraft slewed off the runway and pivoted around the right engine during the landing at Hamilton.

2.4 During the landing at Gisborne the left undercarriage outboard lower drag brace failed because a fatigue crack had started and propagated in the machined grease fitting recess until overload occurred. The failure occurred near the point where the drag brace attached to the undercarriage leg. Once the outboard lower drag brace failed the load was transferred to the inboard drag brace, which then failed in overload in a similar manner through its grease fitting recess.

2.5 Once the fatigue crack had started, each landing cycle would have caused the crack to grow. The drag brace failure was primarily due to the presence of the fatigue crack, not the landing. Uncracked serviceable drag braces should not have failed under those landing conditions. The fatigue crack had reached the critical size necessary to cause a catastrophic failure of the drag brace during the firm landing at Gisborne. The crack was growing rapidly and would have eventually grown to a point where it weakened the drag brace sufficiently for it to have failed during normal use. A similar failure would have occurred at a later date if the aircraft had not landed firmly at Gisborne Aerodrome. The cracking, therefore, had potential to jeopardise the safety of fare-paying passengers.

2.6 Once the drag braces failed the undercarriage leg was free to move aft past its normal vertical down-locked position. This caused the aircraft to swing to the left and the left propeller to strike the runway. Had the crew not carried out an immediate go-around, directional control would probably not have been regained.

2.7 Each landing would have put the drag braces under tension at touchdown. Fatigue cracks propagate incrementally every time the applied stress is higher than the critical level. This propagation can leave a distinctive step (striation) on the fracture surface. Each striation seen occurs as a result of one cycle. If the total number of striations seen on a fracture surface can be counted, the total number of cycles a crack has been propagating for can be determined. The total number of propagation cycles on the cracked drag brace from ZK-RCA was estimated to be not greater than 15 000. Based on the failure from ZK-RCA, the critical size for a crack in the drag braces has been shown to be about 8 mm deep and 10 mm wide.

2.8 Although some minor evidence of corrosion on the drag brace bushings was detected there was no evidence this caused the crack initiation and propagation. The somewhat corrosive New Zealand marine atmospheric environment was unlikely to have been a factor in the start and propagation of the fatigue cracks.

2.9 Analysis of the material compositions of the failed drag braces showed they were not significantly different and the compositions probably conformed to the requirements specified for aluminium alloy 2014, the alloy used in the manufacture of Metro drag braces (refer to 1.10.11).

2.10 The recesses machined in the drag braces to accommodate the grease fittings had square edges, which will have acted as significant stress concentrators. If the recesses had been machined with smooth radiused corners they would not have acted as stress concentrators and cracking probably would not have occurred.

2.11 The manufacturer said it was not aware of any reports of cracked Metro drag braces similar to those found on ZK-RCA and the operator's other Metro aircraft. The manufacturer advised it was aware of several previous cases in other states where the drag braces had failed in overload. The failures occurred when the aircraft was landed short of the threshold and the wheels struck the lip of the runway.

2.12 The drag braces were an on-condition item and did not have an in-service life. The manufacturer required general condition and security checks only. The cracks detected in the operator's other Metros were found using a dye penetrant method of crack detection. An aircraft engineer performing a normal inspection would not have been able to detect the cracks visually unless an approved crack detection method was used. The manufacturer did not require the drag braces to be periodically checked for cracks using an approved non-destructive test.

2.13 The crack in the drag brace from ZK-OAA had started in a similar location to that in ZK-RCA. The presence of this crack and the cracks in the other Metro drag braces detected indicated that the fatigue cracking was a design and inspection problem potentially common to all the same type of aircraft.

2.14 The crew's decision to fly ZK-RCA to Hamilton for the wheels-up landing was prudent because the runway distance used during the landing exceeded the available runway length at Gisborne Aerodrome.

3. Findings

Findings are listed in order of development and not in order of priority.

3.1 The aircraft had a valid Certificate of Airworthiness and its records indicated that it had been maintained appropriately and was operating within the required maintenance period.

3.2 A fatigue crack had started and grown to a critical length in the left undercarriage outboard lower drag brace.

3.3 The fatigue crack had probably been propagating for less than 15 000 landing cycles.

3.4 On landing the cracked left undercarriage outboard lower drag brace failed and transferred the load to the inboard drag brace, which failed in overload.

3.5 A firm landing at Gisborne Aerodrome brought the imminent failure of the drag braces forward.

3.6 The drag braces did not have a limited service life and were not required to be periodically checked for cracking.

3.7 Because the cracks in the drag braces could not be detected visually during the routine inspections required by the manufacturer, an approved non-destructive test was necessary.

3.8 The square edge to the machined recess around the grease fitting acted as a significant stress concentrator, which made the drag braces prone to cracking.

3.9 The cracking of the drag braces resulted from a design deficiency.

3.10 The drag brace cracking was potentially common to all the same type of aircraft.

4. Safety Actions

4.1 On 23 June 2000 the aircraft manufacturer issued Service Bulletins, number 226-32-068 for the Fairchild SA226 series aircraft, and number 227-32-043 for the Fairchild SA227 series aircraft with Ozone Industries 14 500 pound (6578 kg) maximum gross take-off weight, part number OAS5453-5 main landing gear assemblies. The bulletins were essentially the same and called for the main landing gear drag brace links to be routinely checked for cracks in the area of the grease fitting recesses using dye penetrant.

4.2 The manufacturer highly recommended compliance with the Service Bulletin. Initial inspection was to be accomplished within 50 hours, time in service from receipt of the bulletin. The bulletin detailed the checking requirements, the ongoing checks necessary and the criteria for replacement of the drag brace assemblies.

4.3 On 31 July 2000 the New Zealand CAA issued Airworthiness Directive DCA/SA226/41, effective from 3 August 2000, applicable for all New Zealand registered Fairchild SA227 series aircraft with Ozone Industries 14 500 pound (6578 kg) maximum gross take-off weight, part number OAS5453-5 main landing gear assemblies. The directive was issued to prevent failure of the drag brace assemblies and required the assemblies to be inspected per the manufacturer's Service Bulletin.

4.4 The inspection intervals called for by the CAA Airworthiness Directive were more restrictive than those in the manufacturer's Service Bulletin. This took into account the New Zealand operating conditions, experience and the results of the metallurgical examination of the failed and cracked drag braces.

4.5 On 9 August 2000 the manufacturer advised that it was changing the Metro drag brace material from 2014-T6 to tougher 7075-T73 material. The new drag braces will be machined rather than forged and the grease fitting surface will be machined either flat or with a smooth radius. The design was being finalised in August 2000 and was awaiting FAA approval. The drag braces were planned to be in production and available to the field in September 2000.

4.6 The FAA issued Airworthiness Directive AD 2000-17-11, docket 2000-CE-41-AD, for United States registered Fairchild SA226 and SA227 series aircraft, effective from 22 September 2000. The directive's actions were to be accomplished in accordance with the manufacturer's Service Bulletins 226-32-068 and 227-32-043.

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Hon. W P Jeffries
Chief Commissioner