AIRCRAFT ACCIDENT REPORT AND EXECUTIVE SUMMARY

			Reference:	**CA18/2/3/10271**	
Aircraft Registration	**ZS-NSY**	**Date of Accident**	21 February 2023	**Time of Accident**	0615Z
Type of Aircraft	Beechcraft BE-76 Duchess		**Type of Operation**	Training (Part 141)	
Pilot-in-command Licence Type	Commercial Pilot Licence (CPL) Aeroplane		**Age**	61	**Licence Valid**	Yes
Pilot-in-command Flying Experience		**Total Flying Hours**	2 451.7	**Hours on Type**	55
Last Point of Departure	Wonderboom Airport (FAWB), Gauteng Province				
Next Point of Intended Landing	Grand Central Airport (FAGC), Gauteng Province				
Damage to Aircraft	Substantial				

Location of the accident site with reference to easily defined geographical points (GPS readings if possible)

On Runway 17 at FAGC at Global Positioning System co-ordinates determined to be 25°59'08.06" South 028°08'24.55" East, at an elevation of 5 259 feet

Meteorological Information	Wind direction: 190°; Wind speed: 10kts; Visibility: 10km; Temperature: 18°C; Cloud cover: Nil

Number of People On-board	2 + 1	**Number of People Injured**	0	**Number of People Killed**	0	**Other (On Ground)**	0

Synopsis

On Tuesday morning, 21 February 2023, a flight instructor (FI) and two student pilots on-board a Beechcraft BE-76 Duchess aircraft with registration ZS-NSY took off on a local training flight from Grand Central Airport (FAGC) to Wonderboom Airport (FAWB) with the intention to return to FAGC. Both airports are located in Gauteng province. The flight was conducted under visual meteorological conditions (VMC) by day and under the provisions of Part 141 of the Civil Aviation Regulations (CAR) 2011 as amended.

The flight instructor stated that upon arrival at FAGC, air traffic control (ATC) cleared the aircraft for landing on Runway 17 and one of the student pilots was the pilot flying (PF). Following a normal touchdown at a speed of approximately 65 knots, the flight instructor noticed that the aircraft was drifting to the left of the runway and that the left-side wing was slowly sinking more than the right-side wing. The flight instructor took control of the aircraft to maintain directional control; however, the two left-side propeller blades contacted the runway surface and the aircraft departed from the tarred runway and came to a stop on the grass on the left side of the runway. The aircraft sustained substantial damage; there were no injuries reported.

Post-accident examination showed that the left-side landing gear had collapsed due to a fracture on the A-frame which is part of the landing gear down-lock mechanism. According to the metallurgical analysis, the fracture occurred over time.

Probable Cause/s and/or Contributory Factors			
The left-side main landing gear A-frame failed during the landing roll due to a fatigue fracture which initiated from the weld metal bead and progressed to the down-lock mechanism. **Contributing Factor(s)** Improper maintenance (non-compliance to AD). Lack of oversight during the safety audit.			
SRP Date	8 August 2023	Publication Date	18 August 2023

Occurrence Details

Reference Number	**:** CA18/2/3/10271
Occurrence Category	**:** Accident Category 2
Type of Operation	**:** Training Flight (Part 141)
Name of Operator	**:** Lanseria Flight Centre
Aircraft Registration	**:** ZS-NSY
Aircraft Make and Model	**:** Beechcraft BE-76 Duchess
Nationality	**:** South African
Place	**:** Grand Central Airport on Runway 17
Date and Time	**:** 21 February 2023 at 0615Z
Injuries	**:** None
Damage	**:** Substantial

Purpose of the Investigation

In terms of Regulation 12.03.1 of the Civil Aviation Regulations (CAR) 2011, this report was compiled in the interest of the promotion of aviation safety and the reduction of the risk of aviation accidents or incidents and not to apportion blame or liability.

All times given in this report are Co-ordinated Universal Time (UTC) and will be denoted by (Z). South African Standard Time is UTC plus 2 hours.

Investigation Process

The Accident and Incident Investigations Division (AIID) of the South African Civil Aviation Authority (SACAA) was notified of the occurrence on 21 February 2023 at 0700Z. The occurrence was classified as an accident according to the CAR 2011 Part 12 and ICAO STD Annex 13 definitions. Notifications were sent to the State of Registry, Operator and Manufacturer in accordance with CAR 2011 Part 12 and ICAO Annex 13 Chapter 4. The States of Registry, Operator and Manufacturer did not appoint an accredited representative and advisor. An investigator was not dispatched to the accident site for this occurrence.

Notes:

1. *Whenever the following words are mentioned in this report, they shall mean the following:*
   Accident — this investigated accident
   Aircraft — the Beechcraft BE-76 Duchess involved in this accident
   Investigation — the investigation into the circumstances of this accident
   Pilot — the pilot involved in this accident
   Report — this accident report

2. *Photos and figures used in this report were taken from different sources and may have been adjusted from the original for the sole purpose of improving clarity of the report. Modifications to images used in this report were limited to cropping, magnification, file compression; or enhancement of colour, brightness, contrast; or addition of text boxes, arrows, or lines.*

Disclaimer

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Abbreviation	Description
°	Degrees
°C	Degrees Celsius
AD	Airworthiness Directive
AIID	Accident and Incident Investigations Division
CAR	Civil Aviation Regulations
C of A	Certificate of Airworthiness
C of R	Certificate of Registration
CRS	Certificate of Release to Service
EDS	Energy-Dispersive X-ray Spectroscopy
FAGC	Grand Central Airport
FAWB	Wonderboom Airport
ft	Feet
hPa	Hectopascal
kt	Knots
m	Metres
METAR	Meteorological Aerodrome Report
MHz	Megahertz
MLG	Main landing gear
MPI	Mandatory Periodic Inspection
NPRM	Notice of Proposed Rulemaking
NDT	Non-Destructive Testing
PN	Part Number
SACAA	South African Civil Aviation Authority
SAWS	South African Weather Service
SPL	Student Pilot Licence
QNH	Altitude Above Mean Sea Level
VMC	Visual Meteorological Conditions
Z	Zulu (Term for Universal Co-ordinated Time - Zero Hours Greenwich)

1. FACTUAL INFORMATION

1.1. History of Flight

1.1.1. On Tuesday morning, 21 February 2023, a flight instructor (FI) and two student pilots on-board a Beechcraft 76 Duchess aircraft with registration ZS-NSY took off on a local training flight from Grand Central Airport (FAGC) to Wonderboom Airport (FAWB) with the intention to return to FAGC. Both airports are located in Gauteng province. The flight was conducted under visual meteorological conditions (VMC) by day and under the provisions of Part 141 of the Civil Aviation Regulations (CAR) 2011 as amended.

1.1.2. The flight instructor (FI) reported that the first leg from FAGC to FAWB with the first student pilot as the pilot flying (PF) was uneventful, and the aircraft landed safely. The second student pilot took over as the PF for the return leg to FAGC. Whilst inbound to FAGC, the FI reported that they were cleared by the air traffic control (ATC) on frequency 122.8-Megahertz (MHz) to land on Runway 17. Following a normal touchdown at approximately 65 knots, the FI noticed that the aircraft was drifting to the left and that the left-side wing was dropping. The FI took control of the aircraft to maintain directional control. However, the left-side propeller blades contacted the runway surface, and the aircraft departed to the left side of the tarred runway and came to rest on the grass.

1.1.3. Metallurgical analysis and examination post-accident showed that the left-side landing gear collapsed due to a fatigue fracture of the A-frame which is part of the landing gear down-lock mechanism.

1.1.4. The aircraft was substantially damaged, however, all occupants on-board were not injured.

1.1.5. The accident occurred during daylight at Global Positioning System (GPS) co-ordinates determined to be 25°59’08.06” South 028°08’24.55” East, at an elevation of 5259 feet (ft).

Figure 1: Aerial view of the accident site. (Source: Google Earth)

1.2. Injuries to Persons

Injuries	Pilot	Crew	Pass.	Total On-board	Other
Fatal	-	-	-	-	-
Serious	-	-	-	-	-
Minor	-	-	-	-	-
None	2	-	1	3	-
Total	**2**	**-**	**1**	**3**	**-**

Other means people on the ground.

1.3. Damage to Aircraft

1.3.1. The aircraft was substantially damaged during the accident sequence.

Figure 2: The aircraft resting on the left-wing. (Source: FAGC Fire Department)

1.4. Other Damage

1.4.1. None.

1.5. Personnel Information

Flight Instructor

Nationality	South African	Gender	Male	Age	61
Licence Type	Commercial Pilot Licence (CPL) Aeroplane				
Licence Valid	Yes	Type Endorsed	Yes		
Ratings	Instrument and Instructor Rating Grade II				
Medical Expiry Date	30 June 2023				
Restrictions	Wear corrective lenses				
Previous Accidents	None				

Flying Experience:

Total Hours	2451.7
Total Past 24 Hours	1.1
Total Past 7 Days	2.9
Total Past 90 Days	100
Total on Type Past 90 Days	15
Total on Type	55

1.5.1 The flight instructor was initially issued a Commercial Pilot Licence (CPL) Aeroplane on 31 May 2018 in accordance with (IAW) Part 61 of the CAR 2011 as amended. His last licence revalidation was conducted on 22 August 2022 and the licence was reissued on the same date with an expiry date of 31 August 2023.

1.5.2 The flight instructor was issued a Class 1 medical certificate on 1 December 2022 with an expiry date of 30 June 2023, and with a medical restriction to wear suitable corrective lenses.

Student Pilot

Nationality	Motswana	Gender	Male	Age	26
Licence Type	Student Pilot Licence (SPL) Aeroplane				
Licence Valid	Yes	Type Endorsed	Yes		
Ratings	None				
Medical Expiry Date	31 December 2026				
Restrictions	None				
Previous Accidents	None				

Flying Experience:

Total Hours	479.1
Total Past 24 Hours	0.5
Total Past 7 Days	0.5
Total Past 90 Days	1.5
Total on Type Past 90 Days	0.5
Total on Type	8.1

1.5.3 The student pilot had a Commercial Pilot Licence (Aeroplane) that was issued by the Civil Aviation Authority Botswana on 11 November 2017. The student pilot transferred to a different Approved Training Organisation (ATO) in South Africa and was then issued a Student Pilot Licence (SPL) Aeroplane on 9 December 2021 with an expiry date of 11 January 2024. The licence was issued in accordance with Part 61 of the South African CAR 2011 as amended.

1.5.4 The student pilot was issued a Class 2 medical certificate on 1 December 2021 with an expiry date of 31 December 2026 with no medical restrictions.

Aircraft Maintenance Engineer

Nationality	South African	Gender	Male	Age	72
Licence Type	Aircraft Maintenance Engineer				
Licence Valid	Yes	Type Endorsed	Yes		
Ratings	Aeroplanes in group 4 and 5				

1.5.5 The Aircraft Maintenance Engineer (AME) was initially issued the AME licence on 14 February 1980 IAW Part 66 of the CAR. His last licence was renewed on 16 August 2022 with an expiry date of 16 September 2024.

1.6. Aircraft Information

(Source: https://flylegacyaviation.com/fleet/beechcraft-model-76-duchess/)

1.6.1. *Beechcraft Model 76 Duchess*

The Beechcraft Model 76 Duchess is an American twin-engined monoplane built by Beechcraft. The Duchess is a cantilever low-wing monoplane with an all-metal structure, four seats, retractable tricycle undercarriage and a T-tail. It is powered by one 180 hp Lycoming O-360-A1G6D on the left wing and one LO-360-A1G6D on the right wing, which drive counter-rotating, constant-speed two-bladed propellers.

Landing Gear A hydraulic pump driven by an electric motor supplies hydraulic pressure through a manifold and shuttle valve to hydraulic actuators, one mounted in each wheel-well, to extend and retract the landing gear. In the retract mode, the electric motor rotates the pump which forces hydraulic fluid through the manifold to the retract side of the system. The actuator is attached to a machined fitting at the top of the down tube of a spring loaded side brace, known as the A-frame, one of which is installed as part of each side's MLG assembly. The landing gear is held in the up position using an up-lock check valve, in the pump, which retains hydraulic pressure. In the extend mode, the motor rotates the pump in the opposite direction and forces hydraulic fluid through the manifold and shuttle valve to the extend side of the system. MLG down-lock is accomplished by over-centre travel of the spring-held side brace (A-frame).

Airframe:

Manufacturer/Model	Beechcraft Aircraft Corporation / BE-76
Serial Number	ME-114
Year of Manufacture	1979

Total Airframe Hours (At Time of Accident)	10 438.3	
Last Inspection (Date & Hours)	13 December 2022	10 396.6
Hours Since Last Inspection	41.7	
CRS Issue Date	13 December 2022	
C of A (Issue Date & Expiry Date)	19 June 2019	30 June 2023
C of R (Issue Date) (Present Owner)	21 September 2021	
Type of Fuel Used	Avgas 100 LL	
Operating Category	Standard operating category	
Previous Accidents	None	

1.6.2 According to the aircraft airframe logbook, the landing gears were inspected on 13 December 2022 and were found to be in a satisfactory condition during the mandatory periodic inspection (MPI). The landing gear Airworthiness Directive (AD) 97-06-10 which requires the inspection of the main landing gear (MLG) A-frame assemblies for cracks was complied with during the MPI. The AD states: *"This amendment supersedes Airworthiness Directive 91-14-14, which currently requires (repetitive inspection of) the main landing gear (MLG) 'A' frame assemblies for cracks on Raytheon Aircraft Company (Raytheon) Model 76 airplanes (formerly referred to as Beech Model 76 airplanes) and replacing any assembly that is found cracked. AD 91-14-14 resulted from reports of fatigue cracks developing on the MLG 'A' frame assemblies of the affected airplanes. Raytheon has developed improved design MLG 'A' frame assemblies, and the Federal Aviation Administration (FAA) has determined that Model 76 airplanes with an improved design 'A' frame assembly installed on both the left and right MLG should be exempt from AD 91-14-14. This action retains the requirement of repetitively inspecting the MLG 'A' frame assemblies for cracks and replacing any cracked 'A' frame assembly only for those Model 76 airplanes that do not have the improved design parts installed. The actions specified by this AD are intended to prevent MLG failure because of a cracked 'A' frame assembly, which could result in loss of control of the airplane during landing operations."*

1.6.3 The Federal Aviation Administration (FAA) released an AD 21-08-06 which was effective from 24 May 2021 following the reported assembly failures. The AD states: *"The NPRM was prompted by reports of part number (P/N) 105-810023-75 and P/N 105-810023-76 'A' frame assemblies failing due to fatigue cracking, resulting in damage to the propeller and outboard wing area. The FAA determined that the visual and dye penetrant inspections were not adequately detecting cracks in the MLG 'A' frame assemblies because some of the failed parts had been subjected to visual and dye penetrant inspections within 100 hours before the failure. In the NPRM, the FAA proposed to require repetitive magnetic particle inspections which provides quicker results (after testing setup) with improved accuracy. Also, the NPRM reflected that the type certificate for the Model 76 airplane had been transferred from Raytheon to Textron, and that Textron designed new replacement parts P/N 105-810023-0083 (left) and P/N 105-810023-0084 (right) that were not subject to the proposed repetitive magnetic particle inspections. However, the newly designed MLG assemblies are still subject to the repetitive inspections specified in the maintenance manual."*

1.6.4 Page 5 of this AD also states the following: *"Within 100 hours' time-in-service (TIS) after the last dye penetrant inspection is required by AD 97-06-10 or within 12 months after the effective date of this AD, whichever comes first, and thereafter at intervals to not exceed 100 hours TIS or 12 months, whichever occurs first, do a magnetic particle inspection for cracks on the left MLG 'A' frame assembly P/N 105-810023-3, 105- 810023-67, or 105-810023-75*

and the right MLG 'A' frame assembly P/N 105-810023-4, 105-810023-68, or 105-810023-76 and, before further flight, take all necessary corrective actions. Do all actions by following the Accomplishment Instructions, paragraphs 4 through 13 of Beechcraft Mandatory Service Bulletin ***SB 32-4156****, dated May 3, 2019."*

Note: *Magnetic Particle Inspection (MPI) is a non-destructive testing method that can detect surface and subsurface flaws in ferromagnetic materials. MPI is often carried out to help determine an item's fitness for use or conformity.*

1.6.5 According to the airframe logbook, AD 21-08-06 was not complied with during the last maintenance inspection that was conducted on 13 December 2022. During this time, the AD had been effective for more than 12 months. There is no evidence in the airframe logbooks of Non-Destructive Testing (NDT) completed on all landing gear assemblies.

1.6.6 The aircraft was issued a Certificate of Release to Service (CRS) on 13 December 2022 with an expiry date of 12 December 2023 or at 10 446.60 hours, whichever occurs first.

1.6.7 The aircraft had a valid Certificate of Airworthiness (C of A) that was issued by the Regulator (SACAA) on 19 June 2019 with an expiry date of 30 June 2023.

1.6.8 The aircraft was issued a Certificate of Registration (C of R) by the Regulator on 21 September 2021.

1.6.9 The A-frame (Part number: 105- 810023-67) was installed on ZS-NSY during the initial airframe assembly in 1979 and had been in operation for a total of 10 438.3 hours. There was no evidence of any landing gear overhaul recorded in the aircraft logbook. Thus, the gear had been in service for 44 years when it failed.

Engine #1:

Manufacturer/Model	Lycoming
Serial Number	L-25753-36A
Part Number	O-360-A1G6D
Hours Since New	10438.3
Hours Since Overhaul	575.8

Engine #2:

Manufacturer/Model	Lycoming
Serial Number	L-215-71A
Part Number	O-360-A1G6D
Hours Since New	10438.3
Hours Since Overhaul	575.8

Propeller #1:

Manufacturer/Model	Hartzell
Serial Number	FB 266 E
Part Number	HC-M2YR-2CEUF
Hours Since New	10438.3
Hours Since Overhaul	311.7

Propeller #2:

Manufacturer/Model	Hartzell
Serial Number	FB 260 E
Part Number	HC-M2YR-2CEUF
Hours Since New	10438.3
Hours Since Overhaul	311.7

1.7. Meteorological Information

1.7.1. The instructor obtained the following weather report prior to the flight, which was communicated to the investigator through the pilot questionnaire.

Wind Direction	190°	Wind Speed	10kts	Visibility	9999m
Temperature	18°C	Cloud Cover	Clear	Cloud Base	N/A
Dew Point	Unknown	QNH	Unknown		

1.8. Aids to Navigation

1.8.1. The aircraft was equipped with standard navigational equipment as approved by the Regulator (SACAA). There were no recorded defects indicating that the navigational equipment was unserviceable prior to the flight.

1.9. Communication

1.9.1. The aircraft was equipped with a standard communication system as approved by the Regulator. There were no recorded defects indicating that the communication system was unserviceable prior to the flight.

1.10. Airport Information

1.10.1. The Grand Central Airport (FAGC) is a small privately owned airport which is open to public air traffic. It is located in Midrand, halfway between Johannesburg and Pretoria in Gauteng province, South Africa. Prior permission to land at Grand Central Airport is not required for light aircraft; only a radio call is sufficient to notify other traffic if the pilot intends to land.

Aerodrome Location	Midrand, Gauteng Province
Aerodrome Status	Licensed
Aerodrome GPS coordinates	25°59'13.44' South, 028°08'25.97" East
Aerodrome Elevation	5325 feet
Runway Headings	17/35
Dimensions of Runway Used	1828 x 23m
Heading of Runway Used	17
Surface of Runway Used	Asphalt
Approach Facilities	PAPI
Radio Frequency	122.8 MHz

1.11. Flight Recorders

1.11.1. The aircraft was not equipped with a flight data recorder (FDR) or a cockpit voice recorder (CVR), nor was it required by regulation to be fitted to the aircraft type.

1.12. Wreckage and Impact Information

1.12.1 The aircraft landed safely at FAGC, however, during the landing roll the left-side main gear collapsed, and the left-side propeller impacted the ground, causing damage to the blade tips. During the accident sequence, the rotating left-side propeller contacted the runway surface, which resulted in damage to both propeller blades.

Figures 3 and 4: The collapsed landing gear (left) and the damaged propeller blades (right). (Source: FAGC Fire Department)

1.12.2 Damage was also caused to the left-side flap, left-side aileron and the under-surface of the rear part of the aircraft fuselage. The left-side wing contacted the ground during the accident sequence, which caused damage to the skin, aileron and flaps. The left wing upper surface skin exhibited buckling and compression loads caused by impact.

Figure 5: The damaged wing skin and the flight control surface. (Source: FAGC Fire Department)

1.12.3 During recovery of the aircraft, it became evident that the left-side main landing gear (MLG) side brace, referred to as the A-frame assembly, failed. The down tube and the diagonal tube of the A-frame were both found with fractures (see Figures 6 and 7).

Figure 6: The top part of the drag brace.

Figure 7: The failed bottom part of the drag brace.

1.13. Medical and Pathological Information

1.13.1. Not applicable.

1.14. Fire

1.14.1. There was no pre- or post-impact fire.

1.15. Survival Aspects

1.15.1. The accident was considered survivable as no damage was caused to the cockpit and the cabin structure of the aircraft.

1.16. Tests and Research

1.16.1 Following recovery of the ZS-NSY aircraft to the hangar, the operator removed the left-side A-frame from the aircraft's main landing gear and delivered it to the Accident and Incident Investigations Division (AIID) for further analysis. The investigation team was aware that A-frames on the Beechcraft Duchess 76 aircraft models were the subject of earlier airworthiness documentation (see paragraph 1.6.2). Therefore, AIID requested that the A-frame be sent to a specialist facility for a metallurgical examination and analysis.

The preliminary investigation revealed the following:

Feedback:

1. *A fatigue mode fracture (Photo 3) initiated within the weld metal bead and progressed as indicated (Photos 1 and 2, red arrows).*

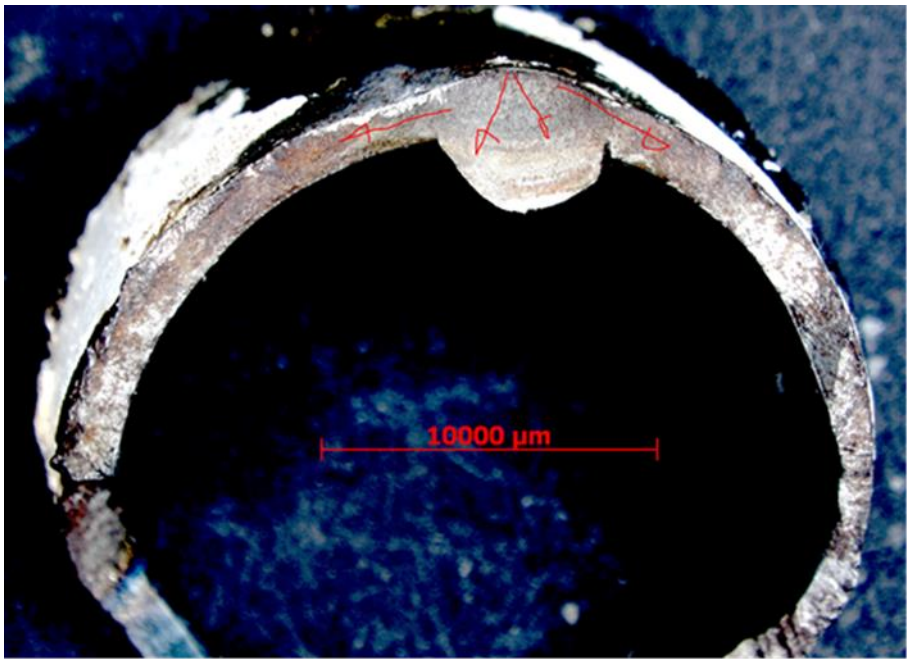


Photo 1

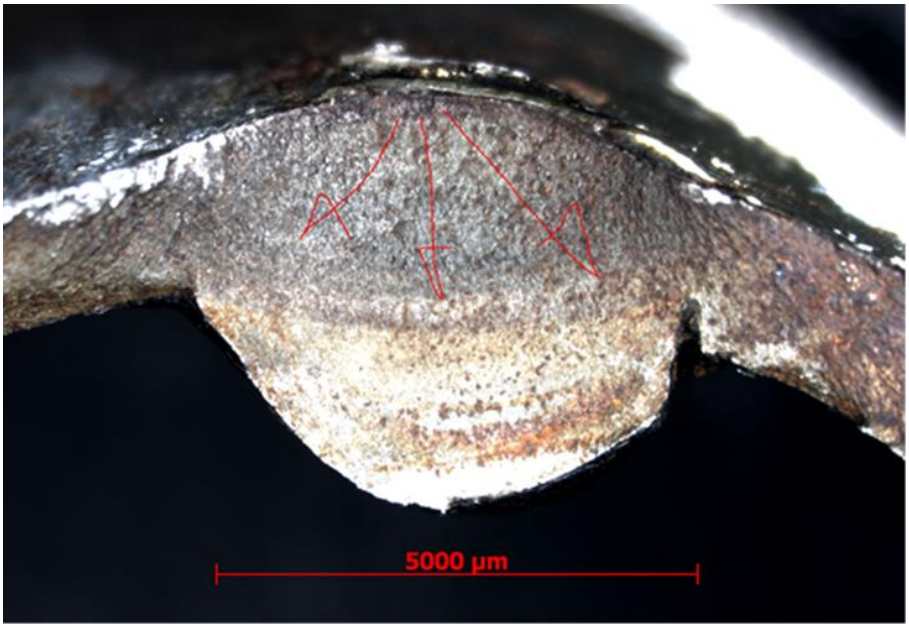


Photo 2

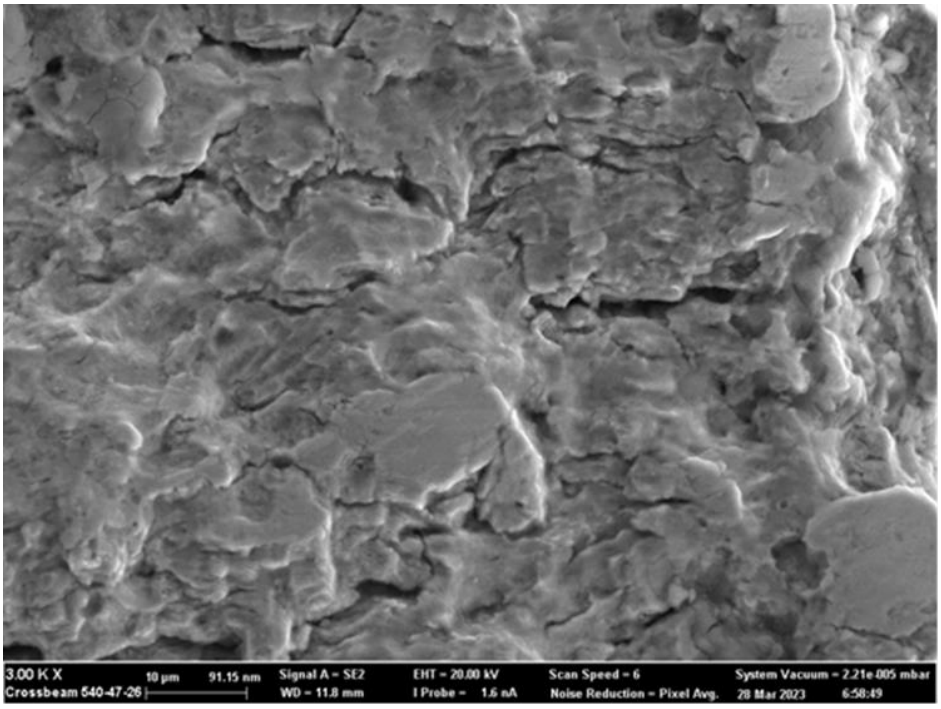


Photo 3

2. *The weld itself revealed some defects i.e., under-cut relating to the quality thereof (Photo 4).*

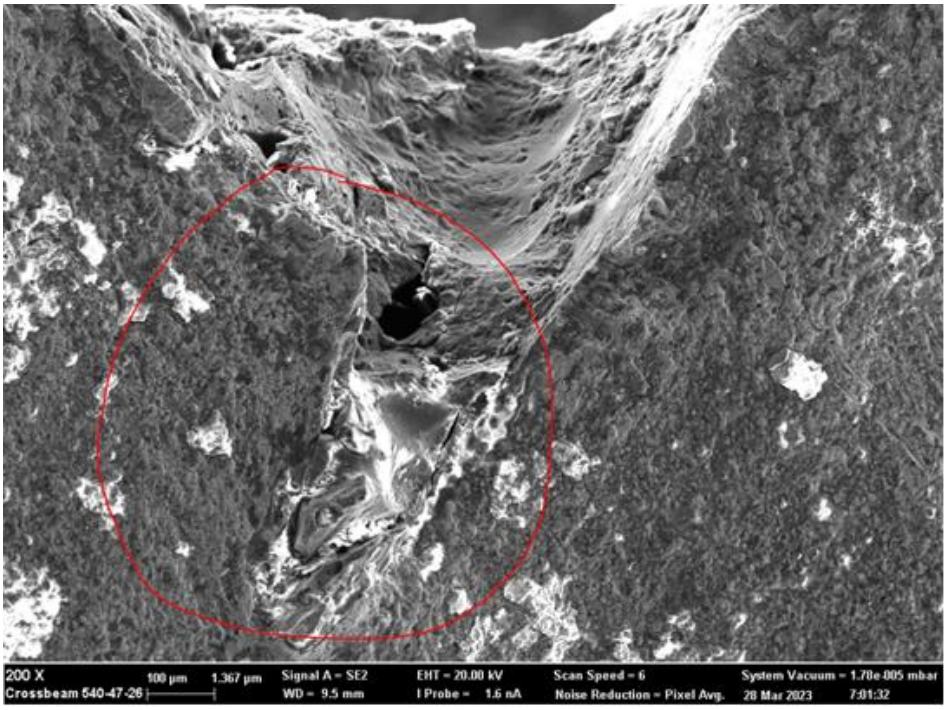


Photo 4

3. *The Maintenance Manual/AD prescribes the removal of the painted layers prior to the NDT inspections - with repainting required afterwards. The paint surrounding the fracture (Photo 5, red arrow, and circle) suggest that it has been exposed for an extended time to the environment (old) while the paint layer surrounding another weldment in close proximity reveals a much newer layer (Photo 5, blue arrow, and circle). It may be an indication that an inspection was performed but possibly at the wrong location/weldment.*

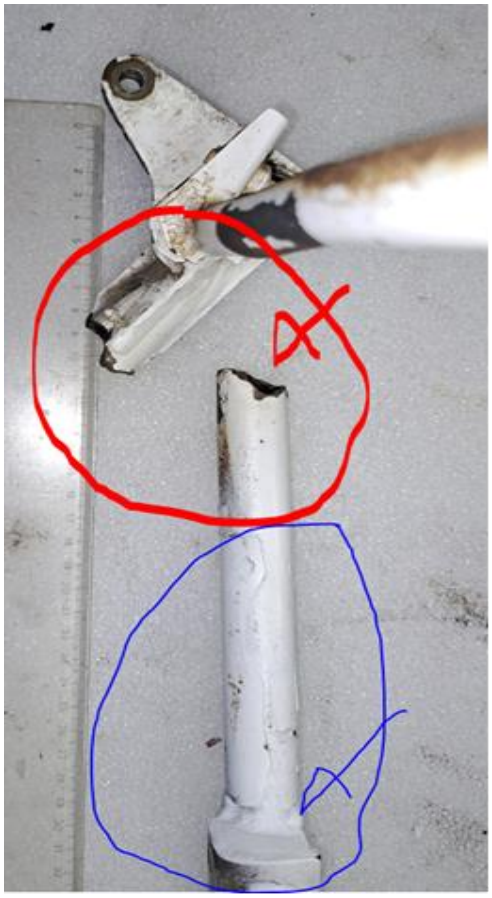


Photo 5

1.16.2 The final investigation revealed the following in addition:

- *The visual inspection revealed a fracture within the tubular section of the MLG "A" frame (Photo 2, Diagram2 1 and 2, red dashed circles) The fracture initiated within the weld metal area (Diagram 2, green arrow; Photos 3 and 4, red arrows).*

Photo 2: Main Landing Gear Leg, as supplied (digital)

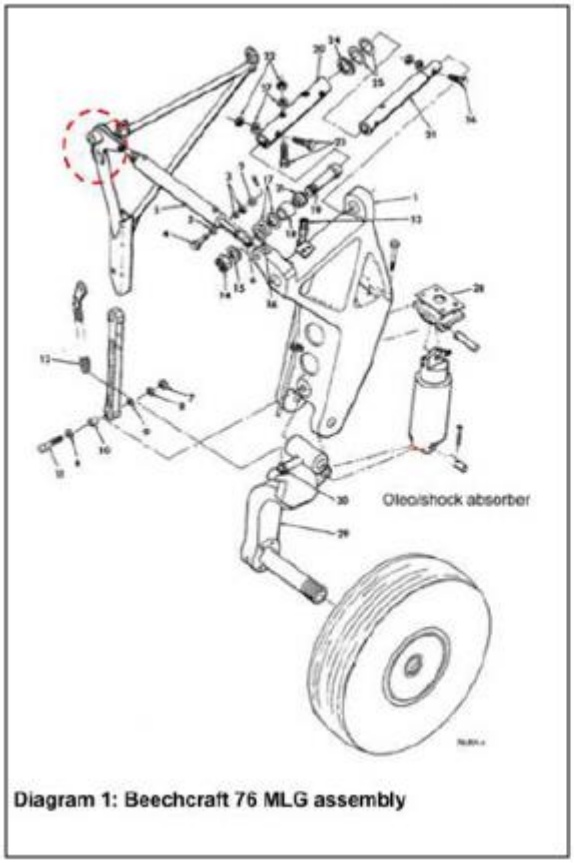


Diagram 1: Beechcraft 76 MLG assembly

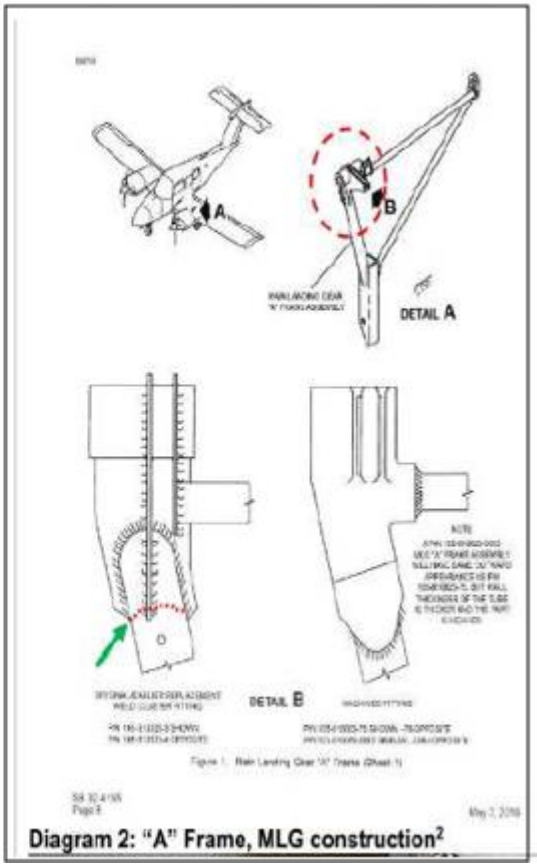


Diagram 2: "A" Frame, MLG construction[2]

- *The outer surface inspection revealed a relatively new painted layer (Photo 5, blue dashed square) surrounding another welded section while the paint layer surrounding the fracture initiation location revealed indications of extended environment time exposure (Photo 5, red dashed circle).*

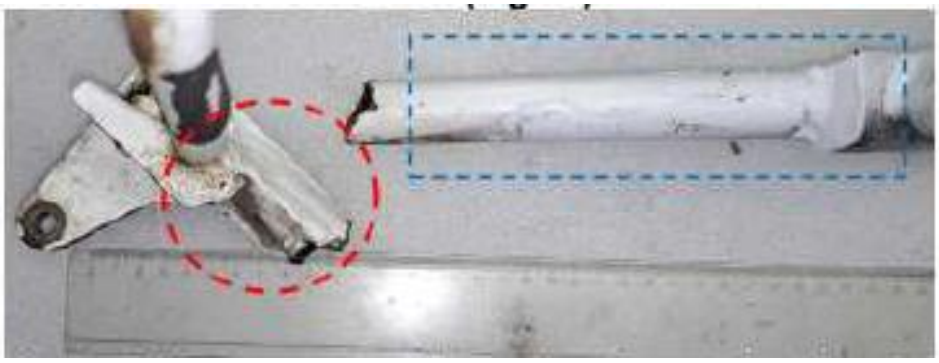
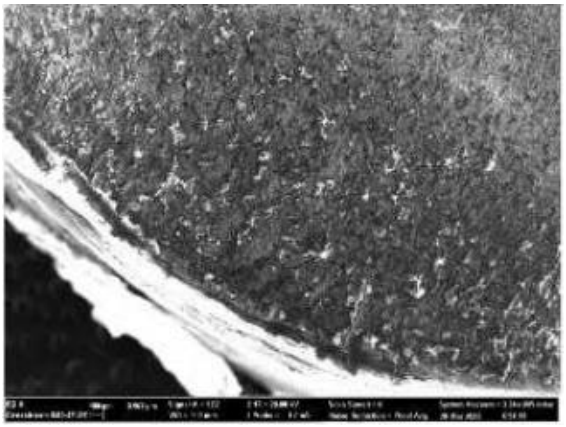
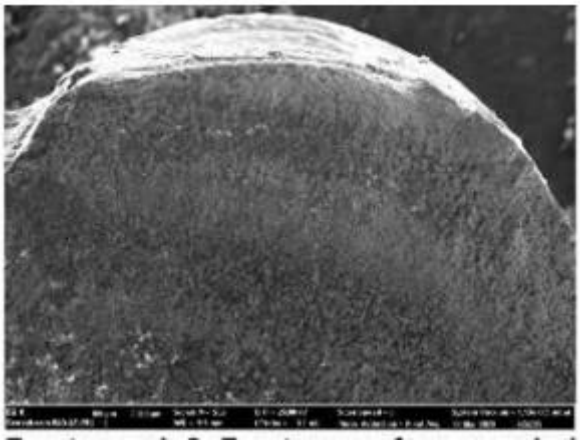


Photo 5: Component surface showing repainted regions (stereo)

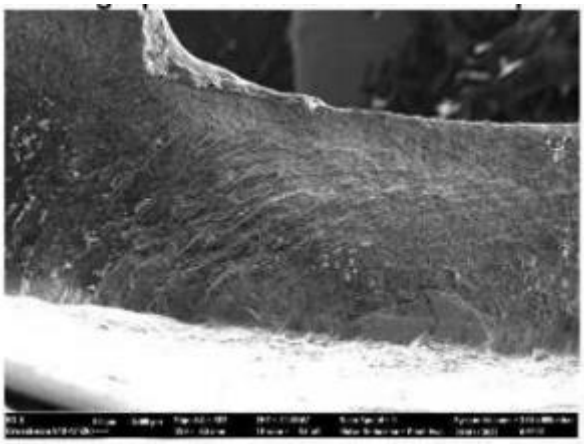
- *Higher magnification inspections revealed excessive foreign deposits at the fracture initiation zone (Fractographs 1, 2 and 3). This is indicative of exposure to the operating environment for an extended period.*



Fractograph 1: Fracture surface morphology, initiation area (69X, SE1, SEM)

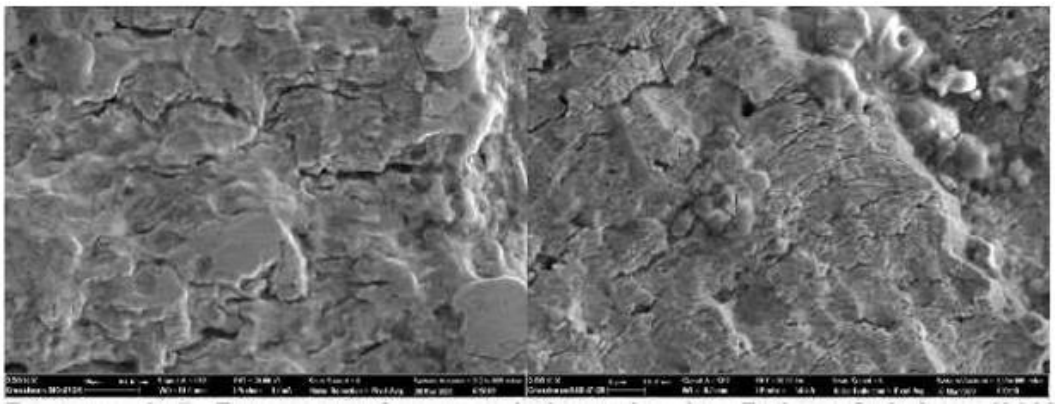


Fractograph 2: Fracture surface morphology, weld metal area (69X, SE1, SEM)

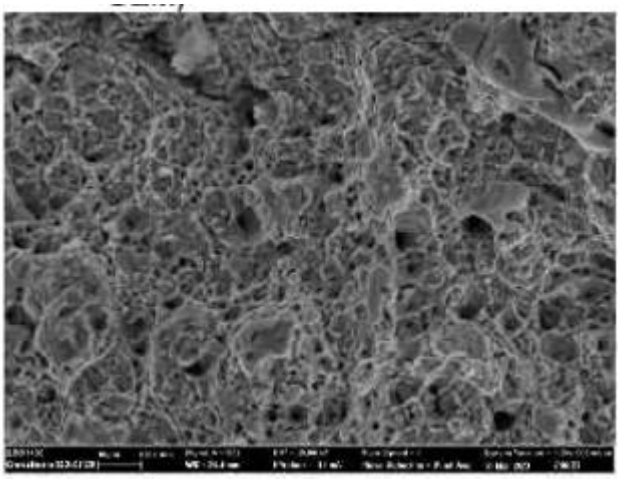


Fractograph 3: Fracture surface morphology, wall thickness, showing fatigue induced "beachmark" (80X, SE1, SEM)

- *Clear beachmarks (Fractograph 3) and striations (Fractograph 5) sanctions the primary failure mode to be fatigue (compared to an overload morphology – Fractograph 6)*

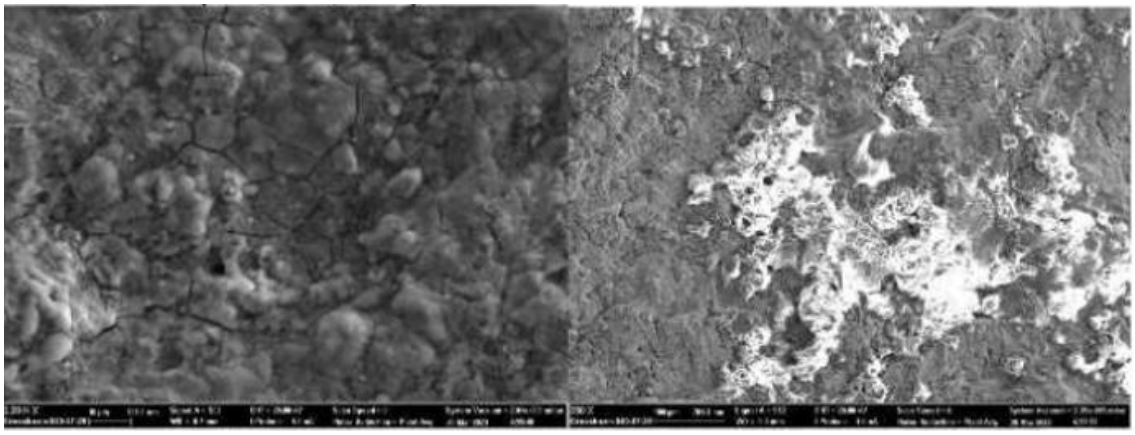


Fractograph 5: Fracture surface morphology showing fatigue striations (2000-3000X, SE1, SEM)



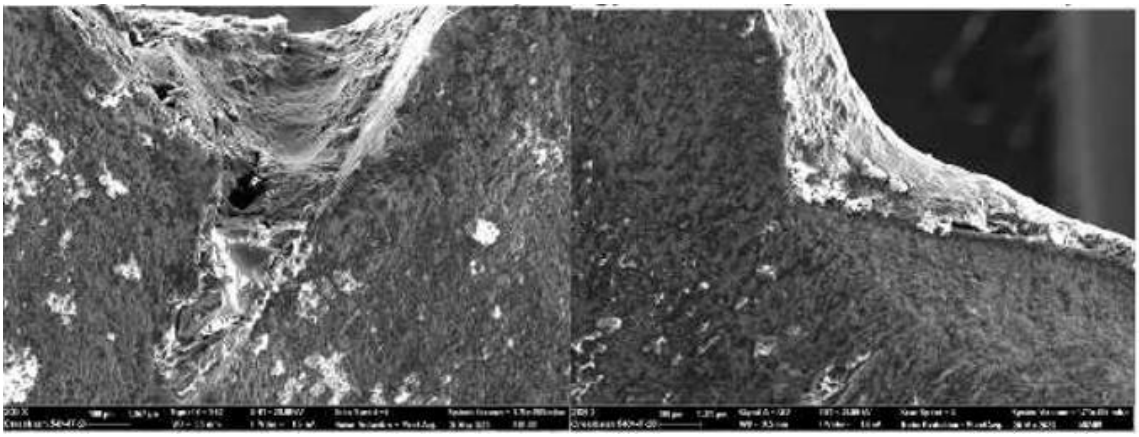
Fractograph 6: Fracture surface morphology, Laboratory induced overload (2000X, SE1, SEM)

- *Extensive foreign deposits on the original fatigue fracture surface morphology (Fractograph 4) supports the notion of an extended environmental exposure period.*



Fractograph 4: Fracture surface morphology showing foreign deposits (350-2000X, SE1, SEM)

- *Dimensional welding defects i.e., undercut, were noted at the foot of the cord (Fractograph 7).*



Fractograph 7: Fracture surface morphology showing welding induced defects (200-208X, SE1, SEM)

- *The EDS MAP results (EDS Result 1) confirmed the noted fracture surface foreign deposit elements to be related to typical environmental exposure – Si (sand particles), Na+CI (salt), C (oil, soot) and Ti (paint).*

  Research
  (Source: Air Accident Investigation Unit Ireland)
  Accident - Beechcraft Duchess 76, EI-BUN Weston Aerodrome (EIWT) 22 May 2014

  In 1991, the FAA issued AD 91-14-14 to address the development of cracking and subsequent failures in the original MLG A-frame assemblies installed on Beechcraft Duchess 76 aircraft. AD 91-14-14 mandated repetitive inspections for cracks. This AD was superseded in 1997 by AD 97-06-10 which stated that aircraft with "improved" MLG A-frame assemblies were exempt from the repetitive inspections. The original A-frame utilised a welded cluster at the top of the down tube, whereas the improved assembly utilised a machined fitting with the down tube fillet welded into the fitting. AD 97-06-10 references Raytheon Mandatory Service Bulletin (SB) No. 2361, Revision III dated June 1996. This SB details fatigue crack inspection procedures for Beechcraft Duchess 76 A-frames unless the improved assemblies, identified by P/Ns 105-810023-75 (L/H) and 105-810023-76 (R/H), had been installed. In accordance with SB No. 2361 Revision III, AD 97-06-10 required that aircraft which did not have the improved A-frame assemblies should be inspected for cracks in areas adjacent to the welded cluster, using both visual and dye penetrant methods, at intervals not exceeding 100 hours' time-in-service. In 2012, the FAA issued SAIB CE-12-34 which is reproduced at Appendix A. This Bulletin was intended to inform interested parties of cracking of P/Ns 105-810023-75 and -76 A-frames. The SAIB states, "Since the issuance of AD 97-06-10, there have been several reports of cracking (or even complete failure during landing and taxi operations) of P/Ns 105-810023-75 and 105-810023-76. Hawker Beechcraft Corporation and the FAA have been unable to determine whether the cracking is due to fatigue, static overload, or poor maintenance." The SAIB continues, "The FAA recommends continuing inspection of the "A" frame assemblies with P/Ns 105-810023-75 and 105-810023-76 even though AD 97-06-10 does not mandate such an inspection. Performing a 100-hour repetitive inspection, at a minimum, is still recommended."

The US National Transportation Safety Board (NTSB) informed the Investigation of an accident in 2009 (NTSB ID WPR09LA383) in which a Beechcraft Duchess 76 sustained substantial damage following the collapse of its L/H MLG. The aircraft had come to a halt just after landing and taxiing to a parking area. The NTSB reported that the P/N 105-810023-75 A-frame's down tube had fractured adjacent to its fillet weld. Their examination revealed that the location of the fracture regions in the down tube were consistent with the stresses developed from the bending moments applied to the down tube when raising and lowering the MLG, as well as during take-off, landing and taxiing. Hawker Beechcraft Communiqué #135 issued in 2012 states that the Manufacturer received one report of a crack in P/N 105-810023-75, after an aircraft started to slide while undergoing a ground run on a slick surface. The Communiqué reminds owners and operators of the importance of inspecting aircraft in accordance with the applicable manuals. It states, "The landing gear components (in their entirety) are inspected every 100 hours/annually per the […] Maintenance Manual." It also notes that FAA Advisory Circular 43.13 states, with respect to inspection and maintenance of landing gear, "9-2 GENERAL INSPECTION. A thorough inspection of the landing gear involves the entire structure of the gear, including attachments, struts, wheels, brakes, actuating mechanism for retractable gears, gear hydraulic system and valves, gear doors, and all associated parts. The manufacturer's inspection procedures should be followed where applicable.

g. The entire structure of the landing gear should be closely examined for cracks, nicks, cuts, corrosion damage, or any other condition that can cause stress concentrations and eventual failure." The Operator of EI-BUN put the Investigation in contact with an overseas repair organisation which has accumulated considerable experience with cracked 105-810023-75 and 105-810023-76 A-frames. The repair organisation informed the Investigation that they were aware of more than 30 cracked A-frames which required repair. They provided the Investigation with a number of photographs of failed A-frames, with fractures exhibiting similar features to the failure on EI-BUN. The Investigation provided the FAA with contact details for the repair organisation.

1.17. Organisational and Management Information

1.17.1 The aircraft was operated under the provisions of Part 141 of the CAR 2011 as amended.

1.17.2 The aircraft maintenance organisation (AMO) which conducted the last maintenance inspection prior to the accident flight had an approved AMO certificate that was issued by the Regulator on 25 February 2022 with an expiry date of 23 February 2023.

1.17.3 The ATO which conducted the training flight had an approved ATO certificate that was issued on 23 June 2007 with an expiry date of 30 June 2023.

1.17.4 The last approval for issue or re-issue or amendment or duplicate certificate of airworthiness was signed during the last application on 3 May 2022 and the AD 21-08-06 had already been effective since 24 May 2021. The aircraft was issued a Certificate of Airworthiness (C of A) even though AD 21-08-06 was not complied with.

1.18. Additional Information

1.18.1 Illustrated Parts Catalogue showing the broken A-frame.

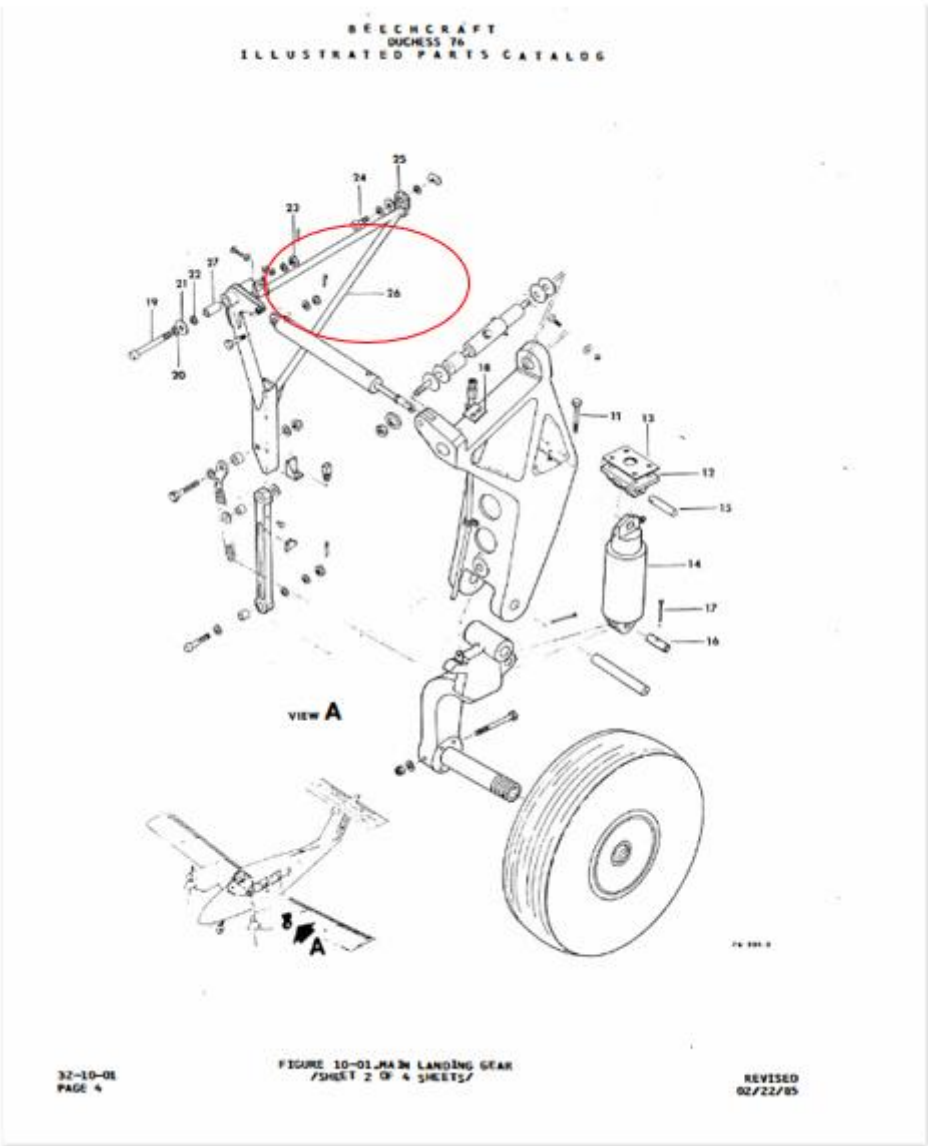
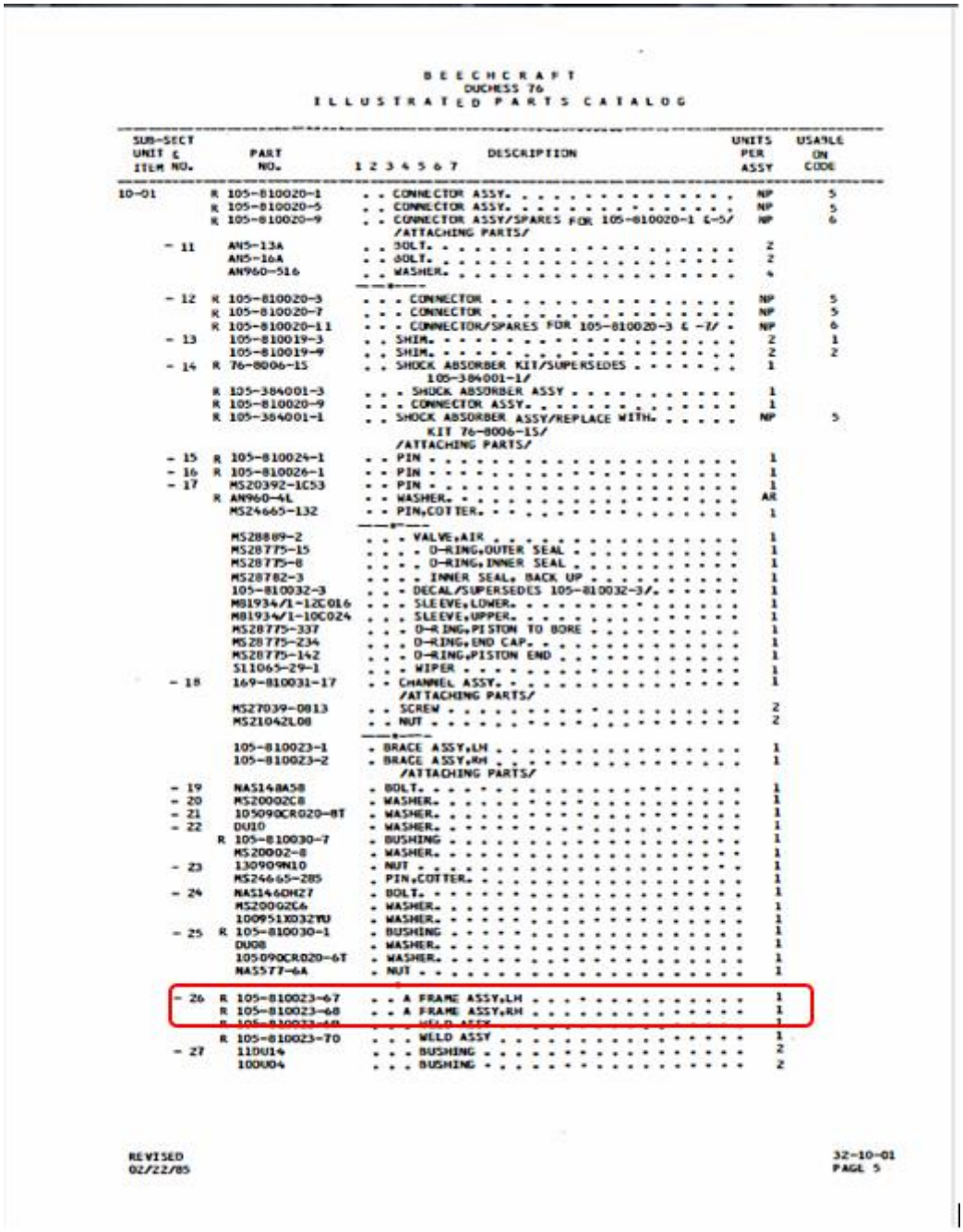


FIGURE 10-01 MAIN LANDING GEAR
/SHEET 2 OF 4 SHEETS/



BEECHCRAFT
DUCHESS 76
ILLUSTRATED PARTS CATALOG

SUB-SECT UNIT & ITEM NO.		PART NO.	1 2 3 4 5 6 7 DESCRIPTION	UNITS PER ASSY	USABLE ON CODE
10-01	R	105-810020-1	. . CONNECTOR ASSY.	NP	5
	R	105-810020-5	. . CONNECTOR ASSY.	NP	5
	R	105-810020-9	. . CONNECTOR ASSY/SPARES FOR 105-810020-1 & -5/ /ATTACHING PARTS/	NP	6
- 11		AN5-13A	. . BOLT.	2	
		AN5-16A	. . BOLT.	2	
		AN960-516	. . WASHER.	4	
- 12	R	105-810020-3	. . . CONNECTOR	NP	5
	R	105-810020-7	. . . CONNECTOR	NP	5
	R	105-810020-11	. . . CONNECTOR/SPARES FOR 105-810020-3 & -7/	NP	6
- 13		105-810019-3	. . SHIM.	2	1
		105-810019-9	. . SHIM.	2	2
- 14	R	76-8006-15	. . SHOCK ABSORBER KIT/SUPERSEDES 105-384001-1/	1	
	R	105-384001-3	. . . SHOCK ABSORBER ASSY	1	
	R	105-810020-9	. . . CONNECTOR ASSY.	1	
	R	105-384001-1	. . SHOCK ABSORBER ASSY/REPLACE WITH. KIT 76-8006-15/ /ATTACHING PARTS/	NP	5
- 15	R	105-810024-1	. . PIN	1	
- 16	R	105-810026-1	. . PIN	1	
- 17		MS20392-1C53	. . PIN	1	
	R	AN960-4L	. . WASHER.	AR	
		MS24665-132	. . PIN,COTTER.	1	
		MS28889-2	. . . VALVE,AIR	1	
		MS28775-15	. . . . O-RING,OUTER SEAL	1	
		MS28775-8	. . . . O-RING,INNER SEAL	1	
		MS28782-3	. . . . INNER SEAL, BACK UP	1	
		105-810032-3	. . . DECAL/SUPERSEDES 105-810032-3/.	1	
		M81934/1-12C016	. . . SLEEVE,LOWER.	1	
		M81934/1-10C024	. . . SLEEVE,UPPER.	1	
		MS28775-337	. . . O-RING,PISTON TO BORE	1	
		MS28775-234	. . . O-RING,END CAP.	1	
		MS28775-142	. . . O-RING,PISTON END	1	
		S11065-29-1	. . . WIPER	1	
- 18		169-810031-17	. . CHANNEL ASSY. /ATTACHING PARTS/	1	
		MS27039-0813	. . SCREW	2	
		MS21042L08	. . NUT	2	
		105-810023-1	. BRACE ASSY,LH	1	
		105-810023-2	. BRACE ASSY,RH /ATTACHING PARTS/	1	
- 19		NAS148A58	. BOLT.	1	
- 20		MS20002C8	. WASHER.	1	
- 21		105090CR020-8T	. WASHER.	1	
- 22		DU10	. WASHER.	1	
	R	105-810030-7	. BUSHING	1	
		MS20002-8	. WASHER.	1	
- 23		130909N10	. NUT	1	
		MS24665-285	. PIN,COTTER.	1	
- 24		NAS1460HZ7	. BOLT.	1	
		MS20002C6	. WASHER.	1	
		100951XD3ZYU	. WASHER.	1	
- 25	R	105-810030-1	. BUSHING	1	
		DU08	. WASHER.	1	
		105090CR020-6T	. WASHER.	1	
		NAS577-6A	. NUT	1	
- 26	R	105-810023-67	. . A FRAME ASSY,LH	1	
	R	105-810023-68	. . A FRAME ASSY,RH	1	
	R	105-810023-70	. . . WELD ASSY	1	
- 27		11DU14	. . . BUSHING	2	
		10DU04	. . . BUSHING	2	

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PAGE 5

1.19. Useful or Effective Investigation Techniques

1.19.1. None.

2. ANALYSIS

2.1. General

From the available evidence, the following analysis was made with respect to this accident. This shall not be read as apportioning blame or liability to any organisation or individual.

2.2. Analysis

2.2.1. Man

The crew was properly licensed and had proper training to undertake the flight. There were no anomalies with the aviation medical records of the instructor. All the available information showed that the crew met all the requirements for this flight. The AME who certified the last maintenance inspection on the aircraft was properly licensed and had the proper training to undertake maintenance. All available information showed that the AME met all the requirements to perform maintenance on the aircraft model.

2.2.2 Machine

Examination of the left-side MLG A-frame by a specialist metallurgists engineer confirmed that a fatigue fracture initiated in the welded metal bead and progressed overtime. This crack was located on the welded face in a particular complex welded region whilst perpendicular to the applied load during operation. The welded area itself revealed indications of undercut on the inner tube side. However, no evidence supports the welding defect to be a contributing factor to the failure.

The investigation found that the AMO did not comply with the Beechcraft mandatory Service Bulletin (SB) 32-4156, dated 3 May 2019 and AD 21-08-06 which was effective from 24 May 2021. These two documents recommended that a magnetic particle inspection be conducted on the main landing gear A-frames at every 100-hour inspection. There was no evidence in the logbook that this was carried out. The MPI was performed twice since the issuance of the SB and the AD. The aircraft had flown a total of 41.7 hours since the last inspection and only AD 97-06-10 was complied with; this inspection is conducted on a painted surface and makes it difficult to notice or identify any sign/s of crack/s. Even though it cannot be confirmed when the crack occurred, it is possible that the initial development of the crack may possibly have been detected using Non-destructive Testing during the last inspection.

It is also possible that the stresses associated with bending applied (were exerted) to the A-frame tube when the MLG was retracting and extending, as well as during landing and taxiing; the failure of the component resulted from overloading. Despite the efforts of the crew to maintain directional control, it was inevitable that the left-side wing would drop due to gravity, which then resulted in the propeller blades contacting the runway surface. The aircraft veered to the left and exited the tarred runway and, thus, the resultant damage to the left-side flap, propellers, aileron and the under surface of the fuselage.

The A-frame was installed on ZS-NSY during manufacture in 1979 and had been in operation for a total of 10 438.3 airframe hours. There was no evidence of the landing gear overhaul recorded in the aircraft logbook; thus, the gear had been in service for 44 years when it failed. The investigation noted that these specific checks of the A-frame recommended by the FAA are mandated as ADs are mandatory and often had time frames by which compliance must be completed.

3. CONCLUSION

3.1. General

From the available evidence, the following findings, causes and contributing factors were made with respect to this accident. These shall not be read as apportioning blame or liability to any organisation or individual.

To serve the objective of this investigation, the following sections are included in the conclusion heading:

- **Findings —** are statements of all significant conditions, events, or circumstances in this accident. The findings are significant steps in this accident sequence, but they are not always causal or indicate deficiencies.
- **Causes —** are actions, omissions, events, conditions, or a combination thereof, which led to this accident.
- **Contributing factors —** are actions, omissions, events, conditions or a combination thereof, which, if eliminated, avoided or absent, would have reduced the probability of the accident occurring, or would have mitigated the severity of the consequences of the accident. The identification of contributing factors does not imply the assignment of fault or the determination of administrative, civil, or criminal liability.

3.2. Findings

3.2.1 The flight instructor had a CPL, and the aircraft type was endorsed on his licence. The flight instructor also had a Class 1 aviation medical certificate that was issued on 1 December 2022 with an expiry date of 30 June 2023.

The student pilot had a CPL (Aeroplane) that was issued by Civil Aviation Authority Botswana and an SPL that was issued in South Africa. The student pilot was issued a Class 2 medical certificate on 1 December 2021 with an expiry date of 31 December 2026 with no medical restrictions.

3.2.2 The aircraft was maintained by an approved aircraft maintenance engineer (AME) with the aircraft type endorsed on his licence, which was initially issued on 14 February 1980. The AME's licence renewal was completed on 16 August 2022 with an expiry date of 16 September 2024.

3.2.3 The aircraft was issued a Certificate of Registration (C of R) by the Regulator on 21 September 2021.

3.2.4 The AMO responsible for the maintenance had released the aircraft with the AD 21-08-06 not having been complied with; the SACAA renewed the Certificate of Airworthiness (C of A) as prescribed by the SA CAR and the South African Civil Aviation Technical Standards (SACAT) 21.08.12A. The aircraft was issued a C of A on 19 June 2019 with an expiry date of 30 June 2023. The aircraft was issued a Certificate of Release to Service (CRS) on 13 December 2022 with an expiry date of 12 December 2023, or at 10 446.60 hours, whichever occurs first.

3.2.5 According to the aircraft maintenance records, the landing gears were last inspected in accordance with AD 97-06-10 and found in a satisfactory condition on 12 December 2022. The recurring landing gear AD 97-06-10 was complied with during the Mandatory Periodic Inspection. However, the AD 21-08-06 which was effective from 25 May 2021 was not complied with during the 50-hour inspection that was carried out on 13 December 2022. The AD 21-08-06 stated that the type certificate for Model 76 airplane had been transferred from Raytheon to Textron, and that Textron had designed new replacement parts, P/Ns 105-810023-0083 (left landing gear) and 105-810023-0084 (right landing gear) that were not subjected to the proposed repetitive MPI.

3.2.6 The last approval for issue or re-issue or amendment or duplicate certificate of airworthiness was signed during the last application on 3 May 2022, and the AD 21-08-06 had already been effective since 24 May 2021. The aircraft was issued a C of A even though AD 21-08-06 was not complied with.

3.2.7 The AMO which carried out the last MPI prior to the accident flight had an approved AMO certificate that was issued by the Regulator on 25 February 2021 with an expiry date of 28 February 2022.

3.2.8 The weather conditions did not have a bearing to this accident.

3.2.9 The left-side main landing gear collapsed during the landing roll after touchdown at 65 kts due to the broken drag brace/A-frame. As a result, the aircraft veered off to the left of the runway before it came to a stop on the grass.

3.2.10 A fatigue fracture initiated in the welded metal bead and progressed overtime. This crack was located on the welded face in a particular complex welded region whilst perpendicular to the applied load during operation. The welded area itself revealed indications of undercut on the inner tube side.

3.3. Probable Cause/s

3.3.1 The left-side main landing gear failed during the landing roll due to fatigue fracture on the A-frame which initiated in the weld metal bead and progressed to the down-lock mechanism.

3.4 Contributing Factor(s)

3.4.1 Improper maintenance (non-compliance to AD).
3.4.2 Lack of oversight during safety audit.

4. SAFETY RECOMMENDATIONS

4.1. General

The safety recommendations listed in this report are proposed according to paragraph 6.8 of Annex 13 to the Convention on International Civil Aviation and are based on the conclusions listed in heading 3 of this report. The AIID expects that all safety issues identified by the investigation are addressed by the receiving States and organisations.

4.2. Safety Recommendation/s

4.2.1. The AMO responsible for the maintenance had released the aircraft with Airworthiness Directive (AD) 21-08-06 not complied with, and the SACAA renewed the Certificate of Airworthiness as prescribed by the SA CAR and SACAT 21.08.12A. It is recommended to the Director of Civil Aviation to consider reviewing their internal processes of verifying and validating the aircraft airworthiness prior to the issuance of the renewed Certificate of Airworthiness.

5. APPENDICES

5.1. Crash Lab report.

This report is issued by:
Accident and Incident Investigations Division
South African Civil Aviation Authority
Republic of South Africa

APPENDIX A

COMPILED BY	Crash LAB	PAGE 1 OF 10
COMPILED FOR: Global Av. Claims (AIID)	INVESTIGATION REPORT: MAIN LANDING GEAR ASSEMBLY, BEECHCRAFT 76, AIRCRAFT No ZS-NSY	DOCUMENT NUMBER FA-011-04-23
		DATE 2023-04-17 / ISSUE 1
ITEM:	MAIN LANDING GEAR "A" FRAME, MAIN LANDING GEAR ASSEMBLY, BEECHCRAFT DUCHESS 76, AIRCRAFT NUMBER ZS-NSY	

1. INTRODUCTION & BACKGROUND INFORMATION

1.1. The "A" Frame (Photo 2), forming part of the main landing gear assembly of a Beechcraft 76 Duchess, aircraft registration no ZS-NSY (Photo 1), serial No ME-114, was submitted to determine the most probable contributing factor/s towards failure during operation.

1.2. The FAA (AD2021-08-26) and the OEM (Beechcraft Textron, SB 32-4156) issued documentation relating to scheduled NDT inspections relating to the MLG "A" Frame.

Photo 1: ZS-NSY[1]

Photo 2: Main Landing Gear Leg, as supplied (digital)

1.2. This report is divided into the following sections:

- Introduction & Background Information Par. 1
- Applicable Documents Par. 2
- Investigative Personnel Par. 3
- Apparatus & Investigative Methodologies Par. 4
- Investigation Results Par. 5
- Conclusions & Discussion Par. 6
- Recommendations Par. 7
- Declarations Par. 8

[1] Airteamimages.com

BEECHCRAFT 76 ZS-NSY ©Failure Analysis & Investigation Laboratory (Pty) Ltd

1.3. **List of Acronyms:**

AAI	Aircraft Accident Investigation	MPI	Mandatory Parts Inspection
AC	Advisory Circular	NDE	Non-Destructive Evaluation
AD	Airworthiness Directive	NDI	Non-Destructive Inspection
AISI	American Iron and Steel Institute	NDT	Non-Destructive Testing
AME	Aircraft Maintenance Engineer	NLG	Nose Landing Gear
AMO	Aircraft Maintenance Organization	OEM	Original Equipment Manufacturer
ASI	Air-Speed Indication/or	OHSA	Occupational Health and Safety Act
ASTM	American Society for Testing and Materials	POD	Probability of Detection
BE	Big End	QMS	Quality Management System
DPI	Dye-Penetrant Inspection	RC	Rockwell C-scale
EBSD	Electron Back-Scatter Diffraction	RH	Right-Hand
ECSA	Engineering Counsel of SA	RoD	Rate of Descend
EDS	Energy-Dispersive X-ray Spectroscopy	RT	Radiographic Testing
FAA	Federal Aviation Authority	SABS	South African Bureau of Standards
FOD	Foreign Object Damage	SACAA	South African Civil Aviation Authority
HE	Hydrogen Embrittlement	SB	Service Bulletin
HIC	Hydrogen Induced Cracking	SCC	Stress Corrosion Cracking
HSS	High-Strength Steels	SE	Small End
ICAO	International Civil Aviation Authority	SEM	Scanning Electron Microscope
IG	Inter-Granular	TBO	Time Before Overhaul
IR	Infra-Red or Thermal Testing	TG	Trans-Granular
LH	Left-Hand	TSO	Time Since Overhaul
MAUW	Maximum All-Up Weight	TTSN	Total Time Since New
MLG	Main Landing Gear	UT	Ultra-Sonic Testing
MPI	Magnetic Particle Inspection	VSI	Vertical Speed Indication

2. APPLICABLE DOCUMENTS

(a) FAA AD 2021-08-26.
(b) Beechcraft Textron SB 32-4156.

3. INVESTIGATIVE PERSONNEL

(a) The investigative member and compiler of this report is a qualified Physical Metallurgist (Metallurgical Engineering, ECSA Registration: Prof. Eng. Tech. No 201670194), Radiation Protection Officer (RPO, NNR, No 281) and Aircraft Accident Investigator.

4. APPARATUS AND METHODOLOGIES

(a) The methodology included visual inspection of the affected part/s, sample preparation and Light-, Stereo- and FEGSEM/EDS analysis.

(b) Apparatus:

Type	Make/Model
Stereo-Microscope	Zeiss Discover V20
Scanning Electron Microscope	Zeiss 540 Crossbeam FEGSEM
EDS	Oxford Aztec

5. INVESTIGATION RESULTS

The visual inspection revealed a fracture within the tubular section of the MLG "A" frame (Photo 2, Doagrams2 1 and 2, red dashed circles). The fracture initiated within the weld metal area (Diagram 2, green arrow; Photos 3 and 4, red arrows).

The outer surface inspection revealed a relatively new painted layer (Photo 5, blue dashed square) surrounding another welded section while the paint layer surrounding the fracture initiation location revealed indications of extended environmental time exposure (Photo 5, red dashed circle).

Higher magnification inspections revealed excessive foreign deposits at the fracture initiation zone (Fractographs 1, 2 and 3). This is indicative of exposure to the operating environment for an extended period.

Clear beachmarks (Fractograph 3) and striations (Fractograph 5) sanctions the primary failure mode to be fatigue (compared to an overload morphology – Fractograph 6).

Extensive foreign deposits on the original fatigue fracture surface morphology (Fractograph 4) supports the notion of an extended environmental exposure period.

Dimensional welding defects i.e. undercut, where noted at the foot of the cord (Fractograph 7).

The EDS MAP results (EDS Result 1) confirmed the noted fracture surface foreign deposit elements to be related to typical environmental exposure - Si (sand particles), Na+Cl (salt), C (oil, soot) and Ti (paint).

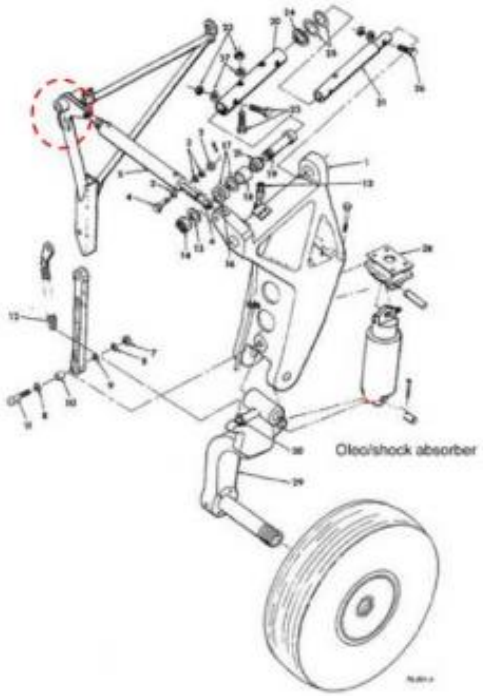


Diagram 1: Beechcraft 76 MLG assembly

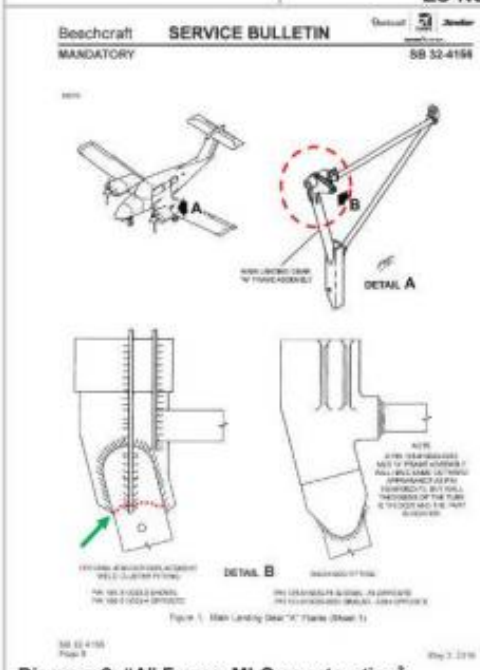


Diagram 2: "A" Frame, MLG construction[2]

Photo 3: Fracture location (digital)

[2] Courtesy Beechcraft Textron

Photo 4: Fracture location (digital)

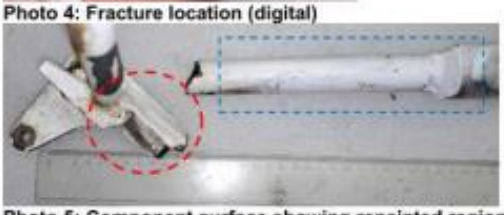
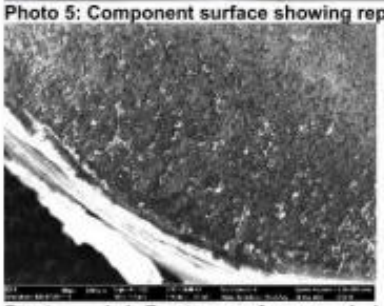
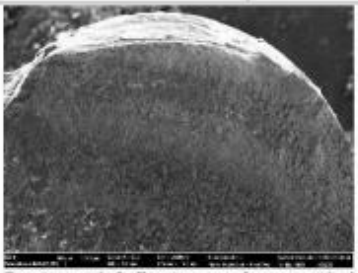


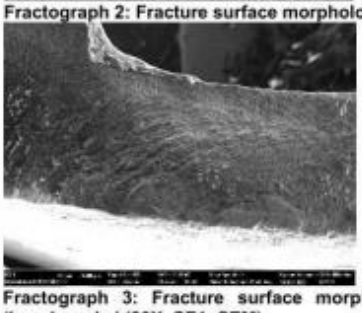
Photo 5: Component surface showing repainted regions (stereo)



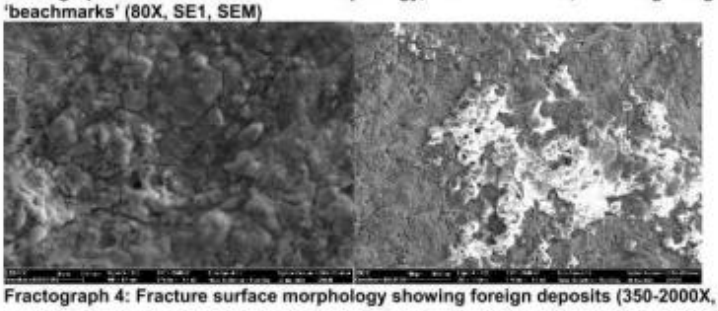
Fractograph 1: Fracture surface morphology, initiation area (69X, SE1, SEM)



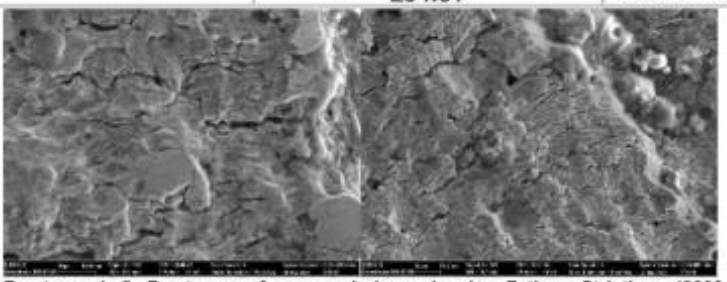
Fractograph 2: Fracture surface morphology, weld metal area (69X, SE1, SEM)



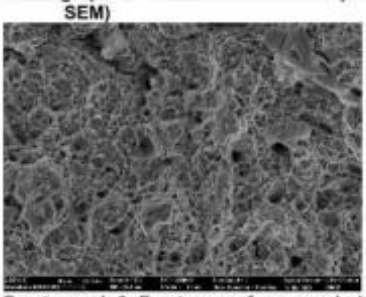
Fractograph 3: Fracture surface morphology, wall thickness, showing fatigue induced 'beachmarks' (80X, SE1, SEM)



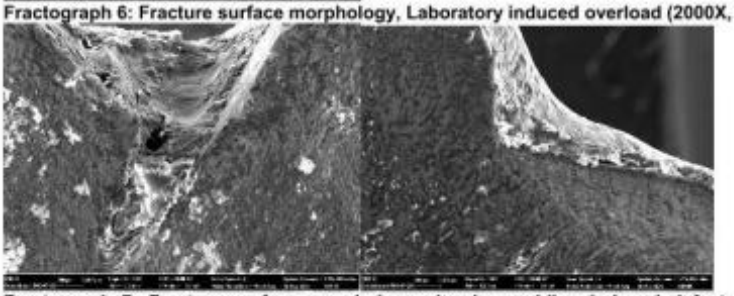
Fractograph 4: Fracture surface morphology showing foreign deposits (350-2000X, SE1, SEM)



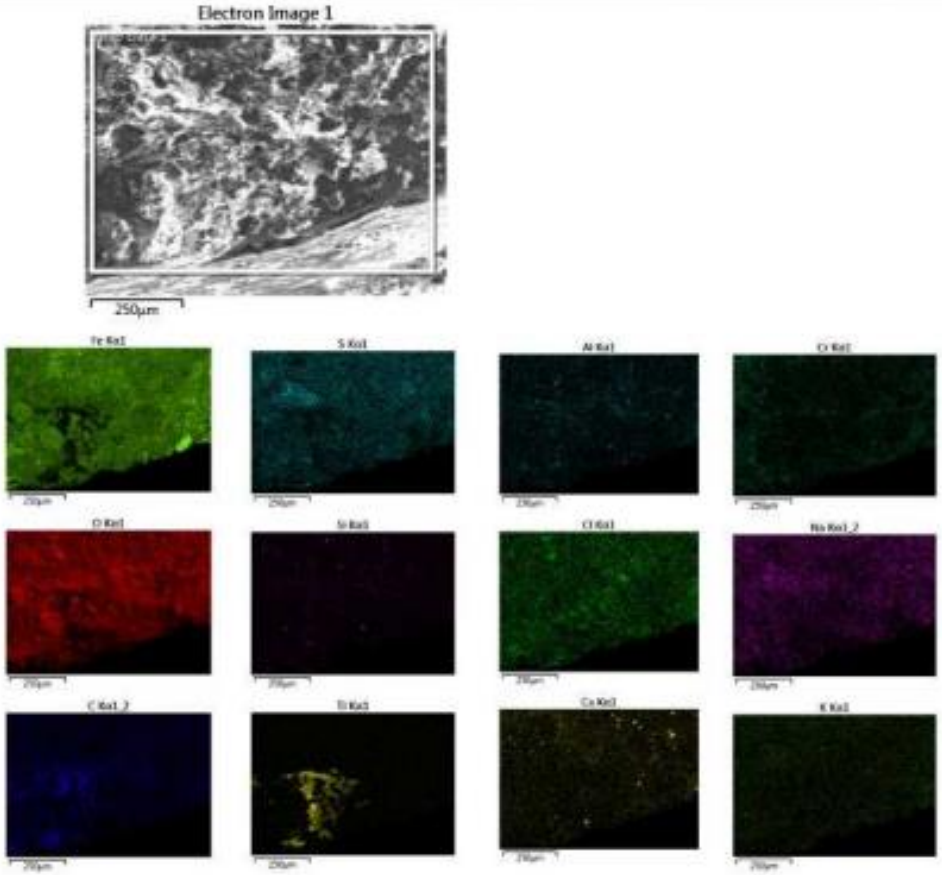
Fractograph 5: Fracture surface morphology showing Fatigue Striations (2000-3000X, SE1, SEM)



Fractograph 6: Fracture surface morphology, Laboratory induced overload (2000X, SE1, SEM)



Fractograph 7: Fracture surface morphology showing welding induced defects (200-208X, SE1, SEM)



EDS Result 1: MAP result from fracture surface contaminants (Oxford Aztec, 20kV, WD 5.5mm, SE)

6. DISCUSSION AND CONCLUSIONS

Applicable Notes:

1. *All conclusions are based on the investigation results obtained from the supplied parts only.*
2. *All written-, electronic- and/or verbal information presented to this investigation are considered as factual.*

6.1 The investigation results revealed a fracture that initiated within the **weld face** within a particular complex welded region while perpendicular to the applied load during operation.

6.2. The weld itself revealed indications of **undercut** on the inner tube side. However, no evidence supports the weld defect to be a contributing factor to the failure. The location of the fracture initiation corresponds with the converging of three different weld metal beads leading to the **complexity** thereof, both in method and resultant metallurgical effects.

6.3. Considering the evidence relating to the variation in painted layer wear and exposure, it suggests that the previous scheduled NDI, if any, was directed at an **improper location** (as per applicable AD and SB).

6.4. The primary mode of fracture is **fatigue**. Fatigue is a time-dependent failure mode suggesting that the fracture was present for an undetermined operational period. The dimensions of the existing fracture should have been detectable with the prescribed MPI NDT methodology (as per applicable AD and SB).

7. RECOMMENDATIONS

7.1. None applicable.

8. DECLARATION

8.1. All digital images have been acquired by the author and displayed in an un-tampered manner, except where stated otherwise.