AIRCRAFT SERIOUS INCIDENT REPORT AND EXECUTIVE SUMMARY

			Reference:	**CA18/3/2/1371**	
Helicopter Registration	ZS-HEW	**Date of Incident**	23 September 2021	**Time of Incident**	1400Z
Type of Helicopter	Schweizer 269C		Type **of Operation**	Game Capture (Part 137)	
Pilot-in-command Licence Type	Commercial Pilot Licence (CPL) Helicopter	**Age**	47	**Licence Valid**	Yes
Pilot-in-command Flying Experience	**Total Flying Hours**	10092.5		**Hours on Type**	377.6
Last Point of Departure	Camdeboo Game Reserve in Graaf-Reinet, Eastern Cape Province				
Next Point of Intended Landing	Camdeboo Game Reserve in Graaf-Reinet, Eastern Cape Province				
Damage to Helicopter	Substantial				

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

Camdeboo Game Reserve in Graaf Reinet, Eastern Cape province at Global Position System (GPS) co-ordinates S 32°13'11.10", E 024°32'28.61" at a field elevation of 2624ft.

Meteorological Information	Wind direction: 220º; Wind Speed: 5kts; Visibility: Good; Air temperature: 18ºC						
Number of People On-board	1+0	**Number of People Injured**	0	**Number of People Killed**	0	**Other (On Ground)**	0

Synopsis

On Thursday, 23 September 2021, a pilot on-board a Schweizer 269C single engine light helicopter with registration ZS-HEW was engaged in a game capture operation in Camdeboo Game Reserve in Graaf-Reinet, Eastern Cape province. The pilot took off from Camdeboo Game Reserve with the intention to return to the same game reserve when the operation was completed. The pilot conducted a pre-flight inspection on the helicopter and nothing abnormal was noted. The aircraft had 12 gallons of Avgas LL100 fuel in the tank and the flight was planned to last about 45 minutes. The pilot lifted off and headed towards the north of the game reserve at a height of 200 feet (ft) above ground level (AGL). At that time, the pilot felt a severe vibration on the tail rotor pedals. The pilot engaged autorotation and, thereafter, landed on the open field. The helicopter's tail rotor assembly and the stabiliser were substantially damaged. The pilot reported no injuries.

According to the metallurgical test report, the fork hinge bolt failed due to the fatigue fracture that initiated in the shank section of the hinge bolt. There was an indication of rotation in the assembly during operation that resulted in localised surface damages (stress raisers) which, in turn, contributed to the initiation of the fatigue fracture. It is likely that several causes, such as under-torque of the bolt, wear/collapse of one or more washers, damages to the fork itself or incorrect assembly during maintenance, might have contributed to this incident.

Probable Cause and Contributory Factor

The helicopter's fork hinge bolt failed on the bolt head due to a fatigue fracture which initiated in the shank section of the hinge bolt over time, causing the imbalance in the tail rotor. This led the pilot to execute an autorotation landing.

- It is likely that several causes, such as under-torque of the bolt, wear/collapse of one or more washers, damages to the fork itself or incorrect assembly during maintenance, might have contributed to this incident. Due to insufficient evidence submitted for testing, the cause could not be determined.

SRP Date	20 September 2022	Publication Date	22 September 2022

Occurrence Details

Reference Number	**:** CA18/3/2/1371
Occurrence Category	**:** Category 2
Type of Operation	**:** Game Capture Part 137
Name of Operator	**:** E'scape Airtours Charters and Transfer CC
Helicopter Registration	**:** ZS-HEW
Helicopter Make and Model	**:** Schweizer 269C
Nationality	**:** South African
Registration	**:** ZS-HEW
Place	**:** Camdeboo Game Reserve in Graaf-Reinet, Eastern Cape Province
Date and Time	**:** 23 September 2021 at 1400Z
Injuries	**:** 0
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 29 September 2021 at 1600Z. The investigator-in-charge did not dispatch to the incident site for this occurrence; instead, the investigation was conducted remotely. The occurrence was classified as a serious incident according to the CAR 2011 Part 12 and ICAO STD Annex 13 definitions. Notification/s were sent to the State of Registry/Operator in accordance with CAR 2011 Part 12 and ICAO Annex 13 Chapter 4.

Notes:

1. *Whenever the following words are mentioned in this report, they shall mean the following:*
   Serious Incident — this investigated serious incident
   Helicopter — the Schweizer 269C involved in this serious incident
   Investigation — the investigation into the circumstances of this serious incident
   Pilot — the pilot involved in this serious incident
   Report — this serious incident 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

Table of Contents

Abbreviation	Description
'	Minutes
"	Seconds
°	Degrees
°C	Degrees Celsius
AGL	Above Ground Level
AIID	Accident and Incident Investigations Division
AME	Aircraft Maintenance Engineer
AMEL	Aircraft Maintenance Engineer Licence
AMO	Aircraft Maintenance Organisation
AMSL	Above Mean Sea Level
AOC	Aircraft Operating Certificate
C of A	Certificate of Airworthiness
C of R	Certificate of Registration
CAR	Civil Aviation Regulations
CPL	Commercial Pilot Licence
CRS	Certificate of Release to Service
CVR	Cockpit Voice Recorder
FDR	Flight Data Recorder
ft	Feet
GPS	Global Positioning System
hPa	Hectopascal
kt	Knots
m	Metres
METAR	Meteorological Aerodrome Report
MHz	Megahertz
Mph	Miles per Hour
MPI	Mandatory Periodic Inspection
No	Number
PIC	Pilot -in-command
QNH	Altitude Above Mean Sea Level
SACAA	South African Civil Aviation Authority
SAWS	South African Weather Service
SB	Service Bulletin
TIS	Time in Service
TML	Period of Validity of the Medical Certificate
VMC	Visual Meteorological Conditions
VML	Correction for Defective Distant, Intermediate and Near Vision
Z	Zulu (Term for Universal Coordinated Time - Zero Hours Greenwich)

FACTUAL INFORMATION

1.1. History of Flight

1.1.1. On Thursday, 23 September 2021, a pilot on-board a Schweizer 269C single engine light helicopter with registration ZS-HEW was engaged in a game capture operation in Camdeboo Game Reserve in Graaf-Reinet, Eastern Cape province. The helicopter had 12 gallons of Avgas LL100 fuel in the tank and the flight was planned to last about 45 minutes. Take-off was from Camdeboo Game Reserve on the residential side, and on a prepared landing zone. The pilot intended to land back on the same take-off spot after completing the operation. The flight was conducted under the provisions of Part 91 of the Civil Aviation Regulations (CAR) 2011 as amended.

1.1.2. According to the pilot, pre-flight inspection was conducted with no anomalies noted. Start-up was carried out with no challenges and the helicopter was configured for take-off. The helicopter lifted off as expected and headed towards the north of the game reserve at a height of 200 feet (ft) above ground level (AGL). At this time, the pilot felt a severe vibration on the tail rotor pedals. He then engaged an autorotation and landed the helicopter on an open field. The helicopter sustained substantial damages to the tail rotor assembly and the stabiliser. The pilot was not injured during the incident.

1.1.3. The incident occurred during visual meteorological conditions (VMC) by day at Camdeboo Game Reserve in Graaf-Reinet, Eastern Cape province, at Global Positioning System (GPS) co-ordinates determined to be S 32°13'11.10" E 024°32'28.61", at 2624 feet (ft) above mean sea level (AMSL).

Figure 1: A view of the incident site. (Source: Google Earth)

1.2. Injuries to Persons

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

Note: Other means people on the ground.

1.2.1. The pilot was not injured during the accident sequence.

1.3. Damage to Helicopter

1.3.1. The helicopter sustained substantial damages to the tail rotor assembly and the stabiliser during the incident sequence.

Figure 2: Damaged fork hinge bolt. (Source: Pilot)

1.4. Other Damage

1.4.1. None.

1.5. Personnel Information

1.5.1. The pilot was qualified and licensed for the flight. He had a Commercial Pilot Licence (Helicopter) that was issued by the Regulator (SACAA) on 25 January 2021, following a currency renewal, with an expiry date of 31 January 2022. The pilot's Class 1 medical certificate was valid. It was issued on 29 June 2021 with an expiry date of 30 June 2022, with a restriction to wear corrective lenses.

Nationality	South African	Gender	Male	Age	47
Licence Type	Commercial Pilot Licence (CPL) Helicopter				
Licence Valid	Yes	Type Endorsed	Yes		
Ratings	Night, Cull, Winching, Test Pilot, Instructor and Sling Load				
Medical Class & Expiry Date	Class 1, 30 June 2022				
Restrictions	TML; VML				
Previous Incidents	None				

Note: Previous serious incidents refer to past serious incidents the pilot was involved in, when relevant to this serious incident.

Flying Experience:

Total Hours	10092.5
Total Past 24 Hours	0.5
Total Past 7 Days	8
Total Past 90 Days	163.5
Total on Type Past 90 Days	82.7
Total on Type	377.6

1.5.2 The aircraft maintenance engineer (AME) was initially issued an Aircraft Maintenance Engineer Licence (AMEL) on 19 December 1986.

Nationality	South African	Gender	Male	Age	64
Licence Type	Aircraft Maintenance Engineer (AME)				
Licence Valid	Yes	Type Endorsed	Yes		
Ratings	Aerospatiale AS 350 Series, Enstrom F28 F280C Series, Hughes/Schweizer 269 Series, Robinson R22 Series, Bell 206L Series, Air& Space 18A, Robinson R44 Series, Mc Donnell Douglas 369 Series, Enstrom 480, Aerospatiale AS 350 (Arriel 2) (Airframe), Bell 206B Series (Airframe), Engines fitted to rotorcraft for which A Cat "A" is held.				
Restrictions	None				
Previous Accidents	None				

1.6. Helicopter Information

The following information is an extract from the Schweizer Model 269C Helicopter Flight Manual: Reissue: 16 January 2019.

1.6.1. *The Schweizer 269C helicopter is a lightweight two-seater single engine equipped with three rotor blades. The helicopter's landing skids are equipped with shock absorbers. The fork hinge is of a teetering mechanism with a bolt to secure the attachment. Originally built by Hughes Helicopters, Schweizer started manufacturing the 269C helicopters under licence from Hughes in 1983 and, about three years later, bought all the licence rights to manufacture the helicopter under Schweizer. The helicopter has a total fuel capacity of 30 US gallons of which 29.8 US gallons is usable.*

On the day of the flight, the helicopter had 12 US gallons of fuel on-board.

Airframe:

Manufacturer/Model	Hughes Helicopter (Sikorsky) Schweizer 269C	
Serial Number	500919	
Year of Manufacture	1980	
Total Airframe Hours (At Time of Serious Incident)	784.1	
Last Inspection (Date & Hours)	3 August 2021	724
Airframe Hours Since Last Inspection	60.1	
CRS Issue Date	22 August 2021	
C of A (Issue Date & Expiry Date)	23 September 2021	31 August 2022
C of R (Issue Date) (Present Owner)	8 March 2017	
Operating Category	Part 127	
Type of Fuel Used	Avgas 100LL	
Previous Incidents	None	

Note: Previous incidents refer to past serious incidents the helicopter was involved in, when relevant to this serious incident.

Engine:

Manufacturer/Model	Lycoming/ HIO-360-D1A
Serial Number	L-21270-51A
Part Number	HIO-360-D1A
Hours Since New	784.1
Hours Since Overhaul	TBO not yet reached

Main Rotor:

Manufacturer/Model	Schweizer 269C		
Serial Number/s			
Rotor Blades	S4572	S4573	S4574
Hours Since New	735.1	735.1	735.1
Hours Since Overhaul	TBO not reached	TBO not reached	TBO not reached
Transmission Type	Main rotor gearbox		
Serial Number/s	2010951		
Hours Since New	784.1		
Hours Since Overhaul	TBO not yet reached		

Tail Rotor:

Manufacturer/Model	Schweizer 269C	
Serial Number/s		
Tail Rotor Blades	S0167	S0173
Hours Since New	735.1	735.1
Hours Since Overhaul	TBO not reached	TBO not reached
Transmission Type	Tail rotor gearbox	
Serial Number/s	B387	
Hours Since New	784.1	
Hours Since Overhaul	TBO not yet reached	

1.6.2. A review of all maintenance documents was conducted, including the helicopter's logbooks, mandatory periodic inspection (MPI) and Service Bulletins (SB) published by both airframe and engine manufactures. The helicopter was initially registered under SACAA registry on 5 October 2010 at 0 airframe hours. The helicopter was transferred three times to different owners following its initial registration. Registration to the second owner was undertaken on 21 June 2012. The helicopter was now registered to the current (third) owner and was issued a Certificate of Registration by the Regulator on 8 March 2017 at 49.4 airframe hours. The helicopter had a valid Airworthiness Certificate, issued by the Regulator on 23 September 2021, with an expiry date of 31 August 2022. The aircraft maintenance organisation (AMO) that serviced the helicopter issued the Certificate of Release to Service (CRS) on 3 August 2021 at 724 airframe hours with an expiry date of 2 August 2022 or at 824 airframe hours, whichever occurs first.

1.6.3. Post-incident examination of the helicopter revealed a broken teetering bolt in the tail rotor assembly. The bolt broke in the solid shaft area and the broken piece was found trapped in the fork area (marked 23 on the tail rotor assembly Illustrated Parts Catalogue [IPC] in Diagram 1). The bolt's function was to secure the tail rotor hub onto the fork. Preliminary investigation revealed that no maintenance was carried out on the tail rotor assembly apart from the daily inspections and the previous MPIs. The helicopter had flown for 784.1 hours since new. The remaining piece of the fork hinge bolt was recovered for further metallurgical testing (Refer to 1.16).

1.6.4. According to available information, the manufacturer released a Service Bulletin B-269.1* on 26 December 2002 which recommended the replacement of 269A6092 BSC or 369A1602 BSC fork hinge bolt with a 269A6092-3 bolt, as well as clarification of the torque specification for the fork hinge bolt. The AMO confirmed that the failed fork hinge bolt was the one recommended by the manufacturer as per the above-stated part number which was likely installed during or following manufacture. According to the Airworthiness Directive (AD) Schedule released in March 2018 by FAA, the DCA/HU269/74 requires modification of fork hinge bolt assembly and accomplish torque checks per Hughes SIN N-155.2 Part I & II, respectively, within the next 100-hour time in service (TIS). The torque checks were also required at 25-hour TIS following modification and, thereafter, at intervals not exceeding 300-hour TIS. The helicopter was at approximately 240.8 airframe hours since new at the time of release of this AD in March 2018. A review of all post-maintenance documents following the release of the AD indicated no records of the fork hinge bolt torque check, as per the required TIS intervals, conducted by the AMO that was maintaining the helicopter. The helicopter had undergone three mandatory periodic inspections (MPI) since the release of the AD and had operated for approximately 543.3 airframe hours until the date of the incident.

1.6.5 SACAA's Certificate of Airworthiness Renewal Approval Information:

According to the ***Certificate of Airworthiness Renewal procedure***, ***AW 005: AIR***, the client is required to submit documentation to be reviewed by an inspector/manager. The AME for ZS-HEW submitted the following information and/or documentation in the Annual Maintenance Review Report on 3 August 2021.

- For the approval of the C of A, provided data must indicate compliance with authority requirements and include manufacturer's recommendations with the application for renewal which includes Federal Aviation Administration (FAA) ADs for the Schweizer 269C helicopter for the inspector to review.

- According to the C of A Renewal Checklist signed on ***23 July 2021***, the signing inspector acknowledged the receipt of the list of Airworthiness Directives performed and the list of manufacturer's mandatory instructions for airworthiness performed, amongst other documentation required for the renewal of the C of A.

1.6.6 Design of the tail rotor hub

The information below is an extract from the Schweizer 269C-1

The tail rotor consists of two blades mounted on a hub assembly (see Figure 1) which is in turn mounted in a rotating fork. The fork incorporates two conical bearings, and a bolt passes through the hub and both bearings. Teetering motion of the rotor is enabled by the presence of the bearings. The bolt, in addition to passing through the bearings and the basic hub trunnion, passes through a shoe, within the hub, which locates the straps holding the two blades against centrifugal force. It also passes through an insert threaded into the hub. Shim washers of various thicknesses bear against the protruding inner races of the conical bearings and enable the pre-load to be adjusted. Two washers of larger diameter, acting as dust shields, are positioned on either side of the hub.

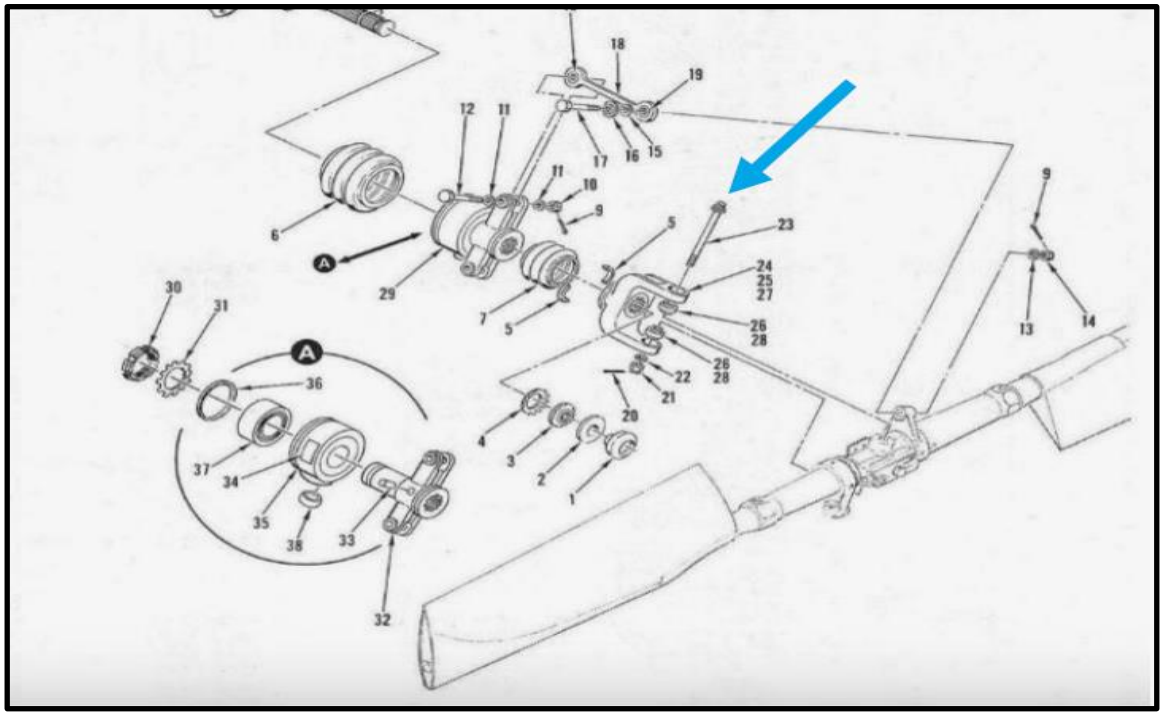


Diagram 1: An illustration of the failed fork hinge on the tail rotor assembly.
(Source: Illustrated Parts Catalogue)

The bolt is secured and tensioned by a nut which, when the assembly is correctly installed, ensures that the inner races, (i.e. the smaller diameter elements of the hub bearings) the nut, bolt, hub, shoe, threaded insert, shim washers and the dust shields all oscillate in unison relative to the fork as the rotor rotates during forward flight.

Maintenance of Hub and Fork assembly requirements and procedure:

According to the 269 Series-Basic Helicopter Maintenance Inspection (HMI), the inspection only addresses the removal of the hub assembly following an inspection, identifying the below conditions on both steel chrome plated trunnions and the maraging steel.

- *For hub with chrome plated trunnions, check surface area on trunnions that mate with blade pitch(feathering) bearings for wear. Wear through chrome plating is not allowed and require hub replacement (HMI Appendix C).*
- *Check visible areas of tension-torsion strap assembly for nicks or scratches on strap laminates, cracked laminates and kinks, sharp bends or permanent twist in laminates. Any one of these defects, except minor outer surface defects that can be removed by rudder abrasive polishing, require replacement of the strap pack assembly.*

There is no information relating to the inspection of the fork hinge bolt.

Layout and Details of the Tail Rotor Hub Components:

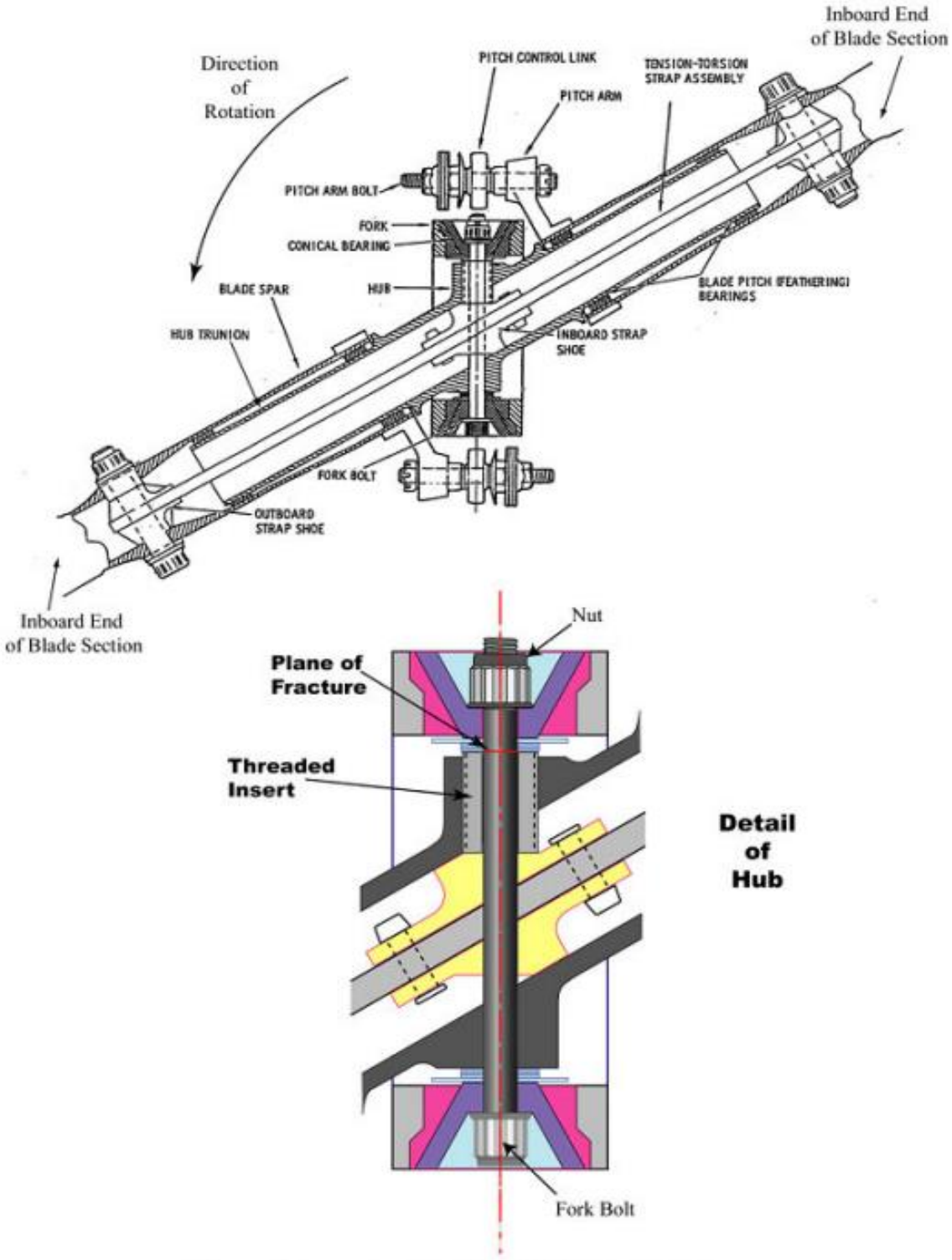


Diagram 2: Layout and details of tail rotor hub components.

1.7. Meteorological Information

1.7.1. The weather information below was obtained from the pilot questionnaire for the accident site on 23 September 2021 at 1400Z.

Wind Direction	220°	Wind Speed	5kt	Visibility	Good
Temperature	18°C	Cloud Cover	None	Cloud Base	None
Dew Point	None	QNH	1019hPa		

1.8. Aids to Navigation

1.8.1. The helicopter was equipped with standard navigational equipment as approved by the Regulator (SACAA). There were no records indicating that the navigation system was unserviceable prior to the serious incident.

1.9. Communication

1.9.1. The helicopter was equipped with a standard communication system as approved by the Regulator. There were no recorded defects with the communication system prior to the serious incident.

1.10. Aerodrome Information

1.10.1. The serious incident did not occur anywhere near an airfield or aerodrome, but at Camdeboo Game Reserve in Graaf-Reinet in the Eastern Cape province, at GPS co-ordinates determined to be S 32°13'11.10" E024°32'28.61", at a field elevation of 2624ft.

1.11. Flight Recorders

1.11.1. The helicopter was neither equipped with a flight data recorder (FDR) or a cockpit voice recorder (CVR), nor was it required by regulation to be fitted to the helicopter type.

1.12. Wreckage and Impact Information

1.12.1 The helicopter experienced vibration after lift-off. Upon noticing the anomaly, the pilot decided to engage/enter autorotation and landed the helicopter on an open field. The helicopter was intact except for the reported failure. No further damages were sustained by the helicopter during the incident sequence.

1.12.2 Upon disembarking the helicopter, the pilot noted dents on the tail stabiliser, as well as damage on the tail boom aft section and on the tail rotor drive shaft link. All damages were sustained during the server vibrations.

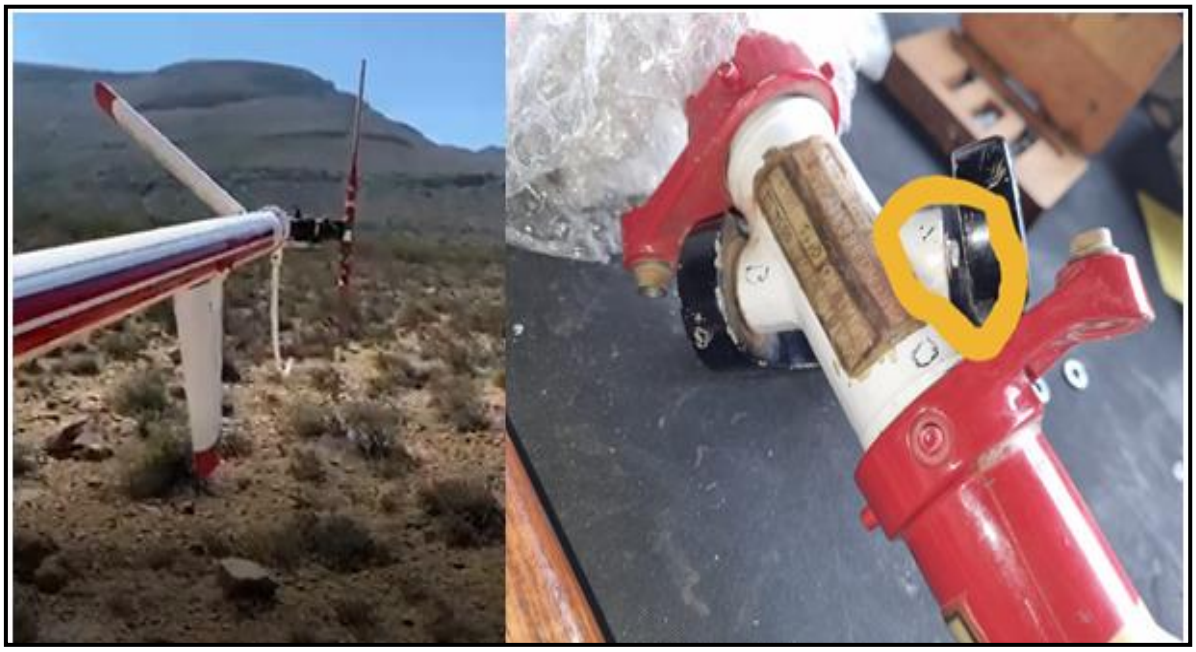


Figure 3: The aft tail boom section and the failed fork hinge bolt.

1.13. Medical and Pathological Information

1.13.1. None.

1.14. Fire

1.14.1. There was no evidence of a pre- or post-impact fire.

1.15. Survival Aspects

1.15.1. The serious incident was considered survivable as the pilot landed the helicopter safely after a successful autorotation. The helicopter did not sustain any damages on the cockpit area that would have compromised the safety of the pilot.

1.16. Tests and Research

1.16.1 The failed fork hinge bolt was recovered and sent for metallurgical testing, carried out on 15 June 2022.

The test results of the failed fork hinge bolt revealed the following:

The visual inspection revealed a fracture within the shank section of the fork bolt at ±59mm from the bolt head base.(Blue arrow; Photo 1). The part number depicted on the bolt head corresponds to the required: 269A6092-3.

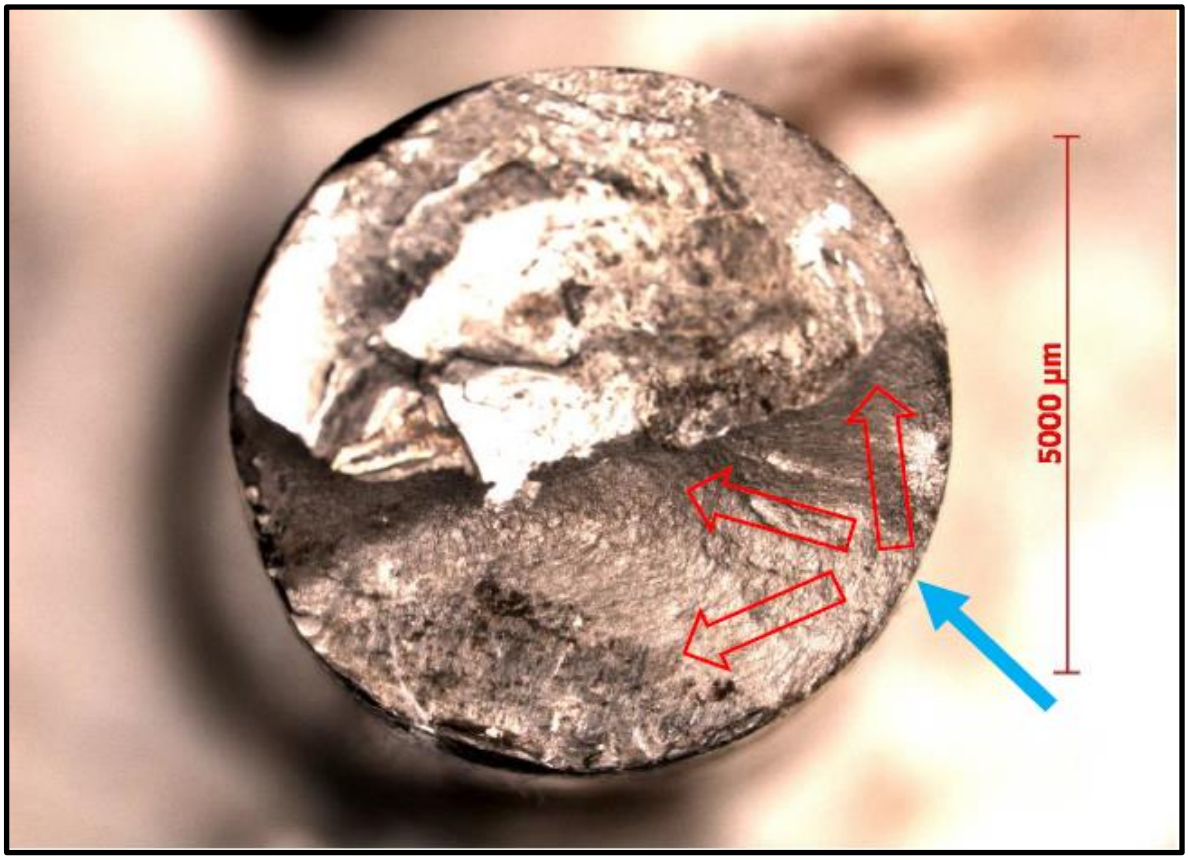
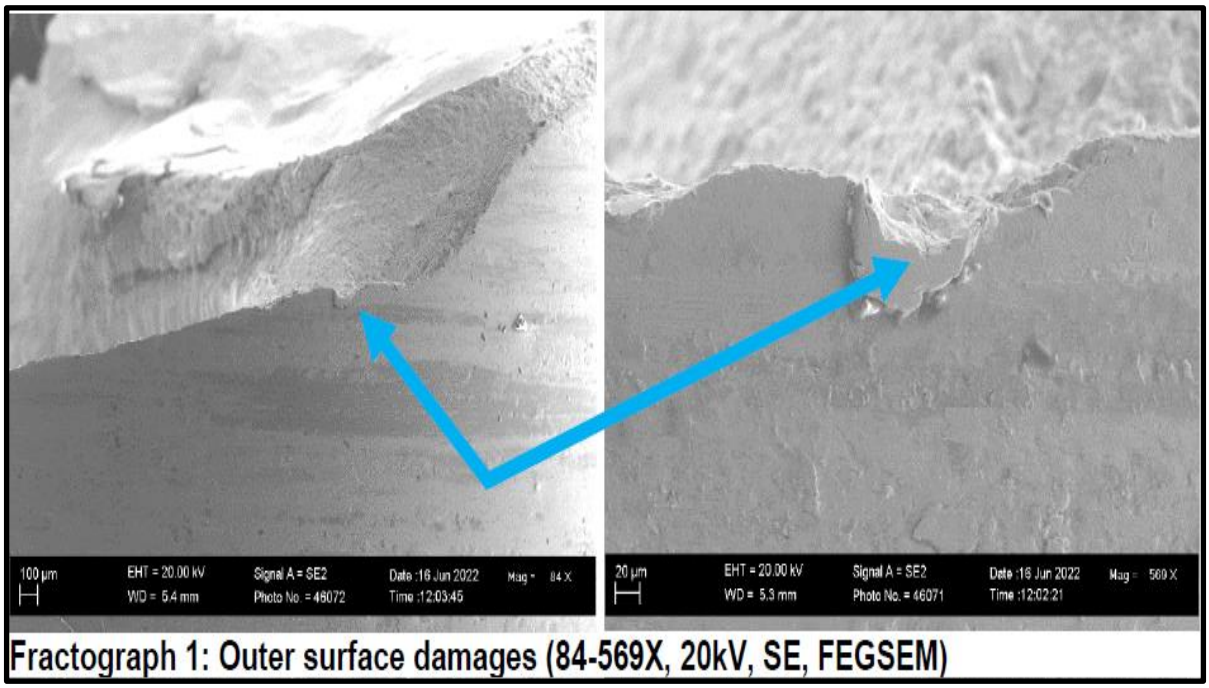
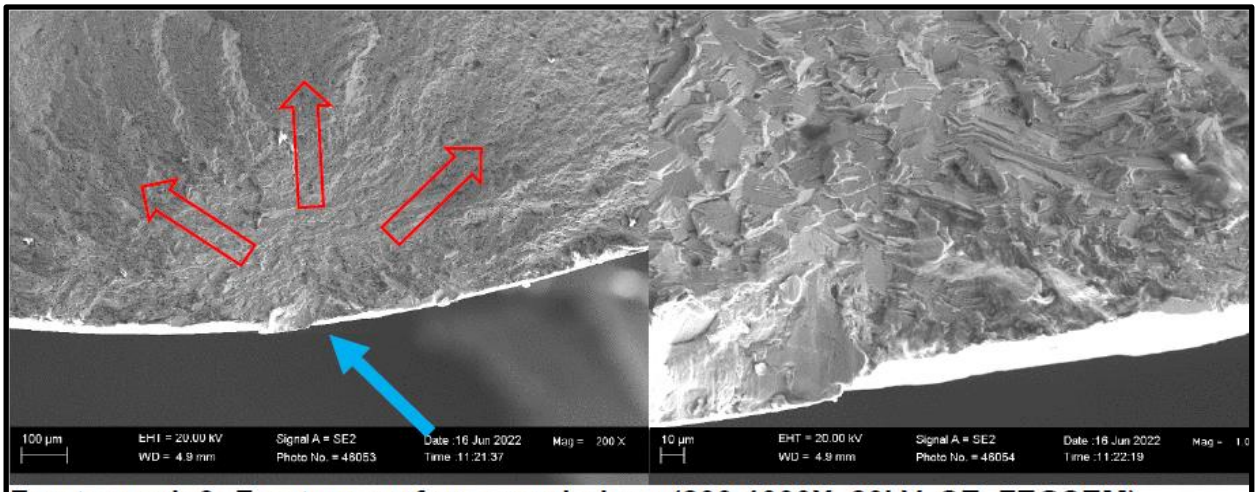


Figure 4 : Facture surface morphology (Stereo).

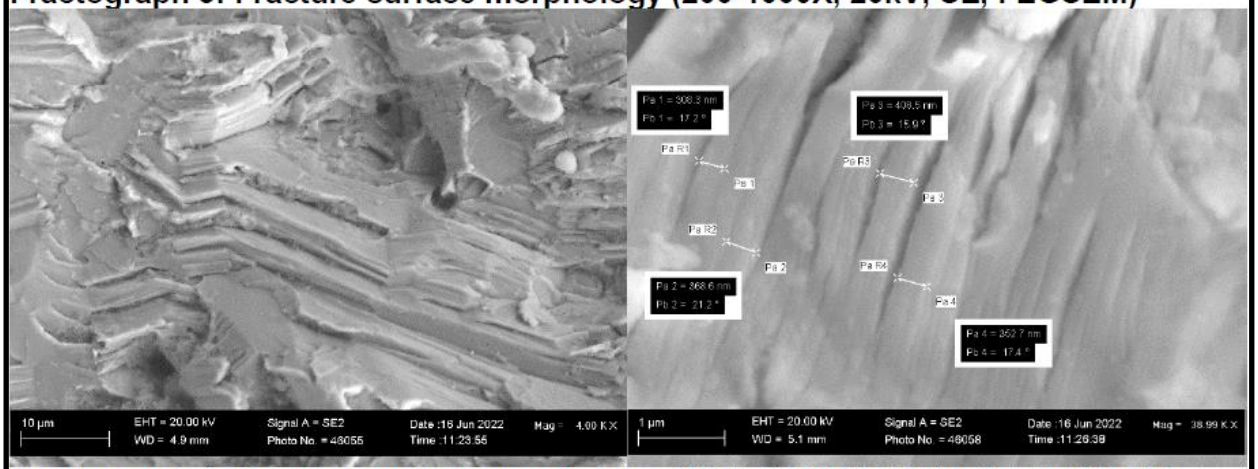
The fracture surface revealed indications towards a predominant fatigue fracture mode with the initiation point (Figure 4, blue arrow; also refer to Fractography 1 and 3, blue arrows) and directions of progression as indicated with red arrows.



Fractograph 1: Outer surface damages (84-569X, 20kV, SE, FEGSEM)

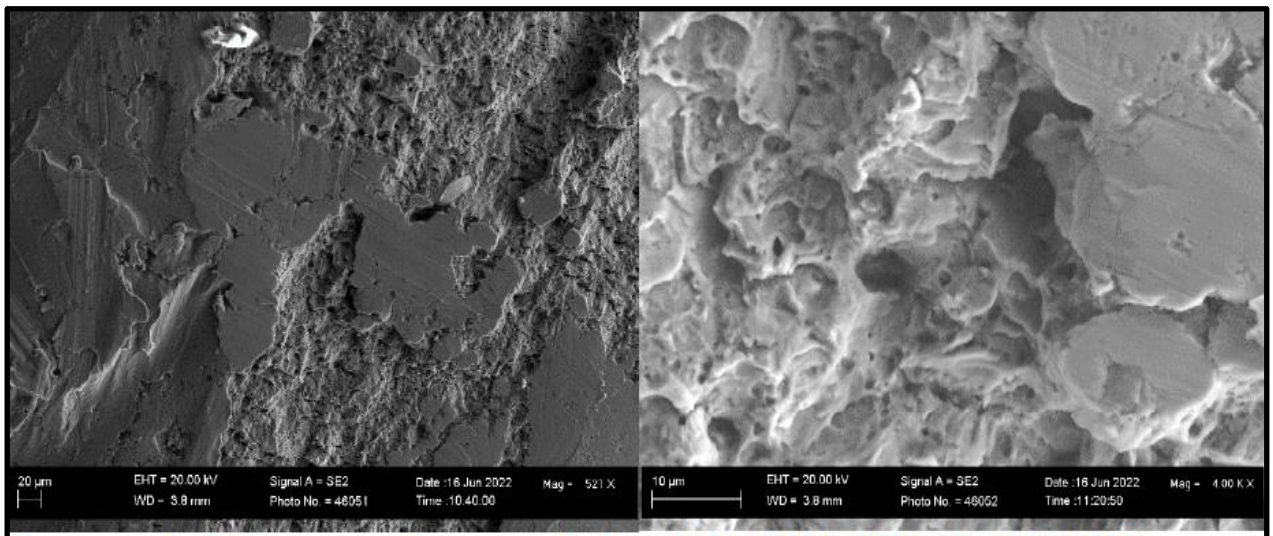


Fractograph 3: Fracture surface morphology (200-1000X, 20kV, SE, FEGSEM)



Fractograph 4: Fracture surface morphology (4000-38990X, 20kV, SE, FEGSEM)

The fatigue mode of failure was confirmed at higher magnifications with the striation spacing (Fractography 3 and 4) suggesting a low stress/high frequency exposure.



Fractograph 5: Fracture surface morphology (521-4000X, 20kV, SE, FEGSEM)

Remnants of the final fracture area revealed a ductile morphology (Fractography 5) within the mechanically damaged surface.

- *The outer shank surface areas adjacent to the bolt head and the fracture locations revealed damages consistent with rotation of the bolt within the assembly during operation (Figures 5 and 6 below, red dashed circles above).*

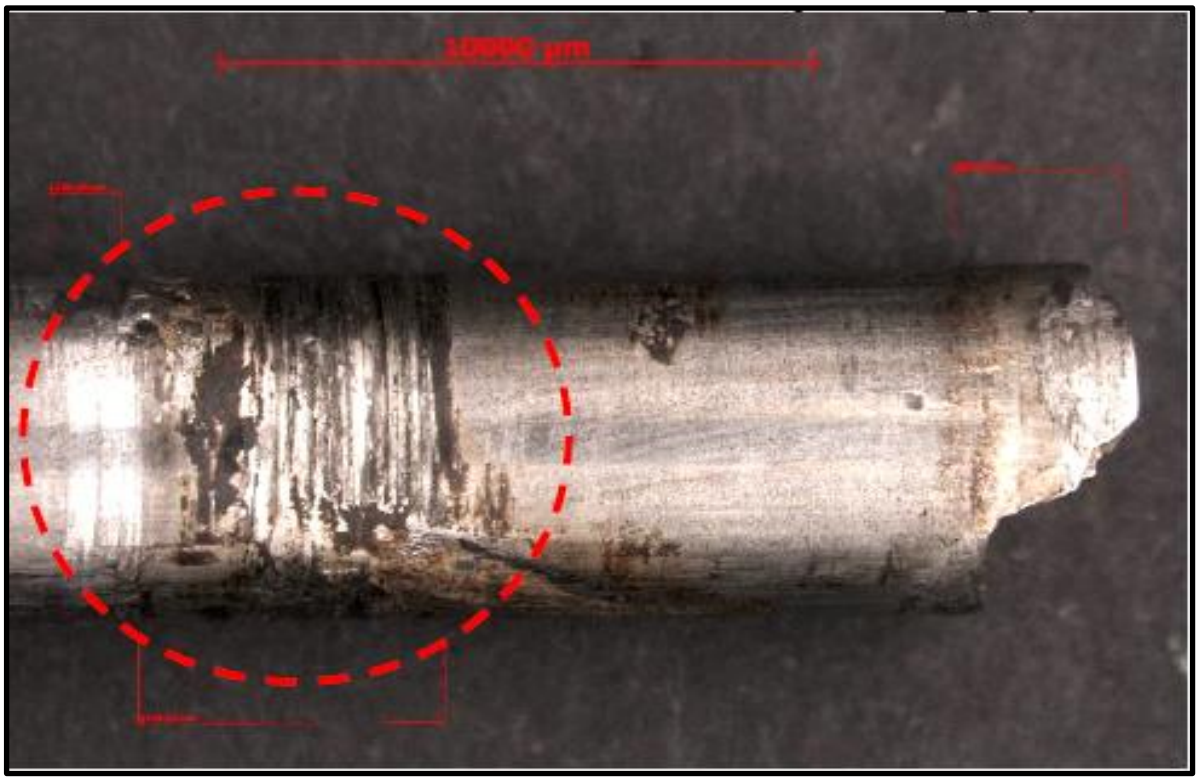


Figure 5: Bolt surface showing rotational damages, fracture end (Stereo).

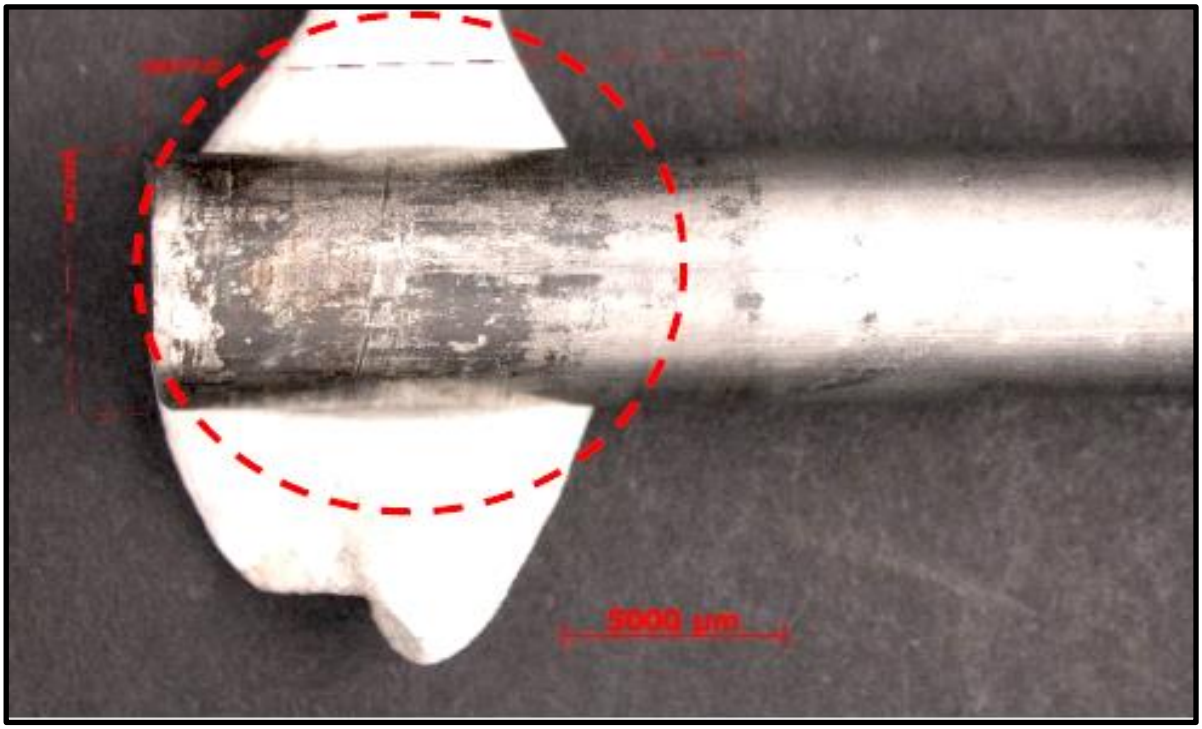
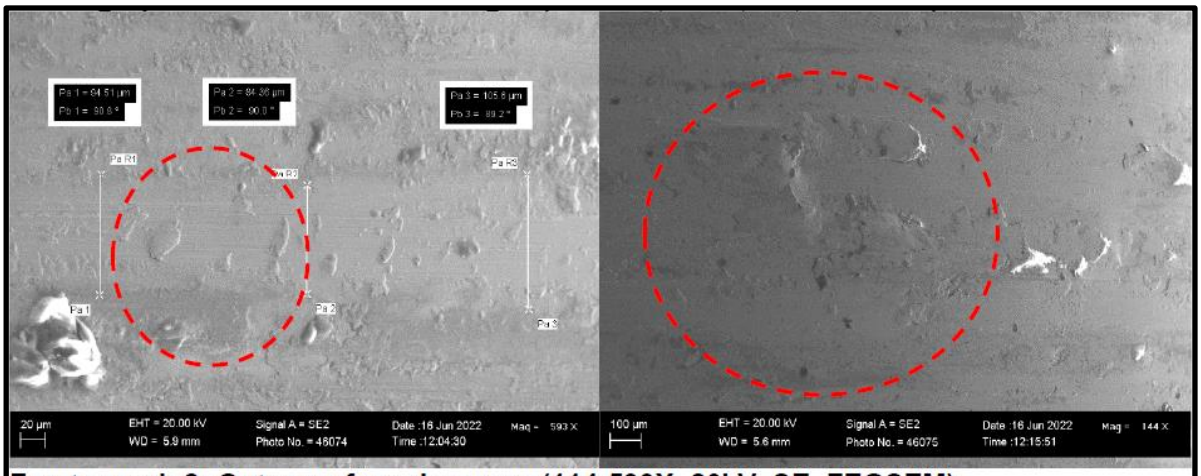


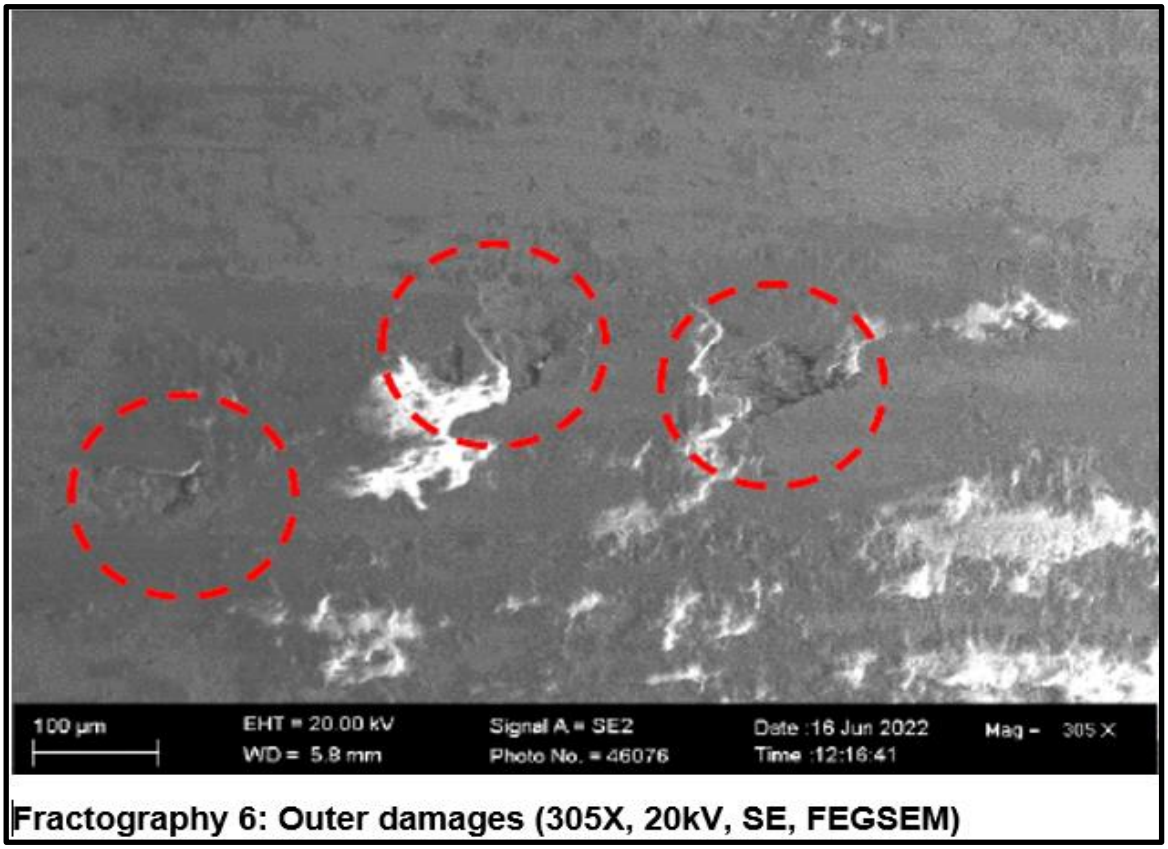
Photo 3: Bolt surface with rotational damages, bolt head end (Stereo).

- *Higher magnification revealed metal smearing and indications of fretting damages (Fractography 1 above and 2 below, red dashed circles) confirming the rotation of the bolt during operation. This is furthermore supported by the noted progression direction changes of the fatigue fracture.*



Fractograph 2: Outer surface damages (114-593X, 20kV, SE, FEGSEM)

The fretting damages, due to the rotation, introduced multiple locations of surface damages (pitting) due to the mechanical fusion between the washers/supports and the bolt surface during operation (Fractography 6, red dashed circles). These surface damages will act as surface stress raisers and will be detrimental to the fatigue resistance of the component. The initiation of the fatigue fracture within the lower stressed shank- rather than the threaded section of the bolt supports this conception.



Fractography 6: Outer damages (305X, 20kV, SE, FEGSEM)

DISCUSSION AND CONCLUSION/S

Note 2: The conclusions are based on the investigation results obtained from the supplied parts/components and information only. All information supplied to this investigation from other parties is considered factual.

- *The investigation results revealed a fatigue fracture mode that initiated in the shank section of the fork hinge bolt.*
- *The bolt proved to conform to OEM specifications.*
- *The bolt rotated within its assembly during operation resulting in localized surface damages (stress raisers) which, in turn, contributed to the initiation of the fatigue fracture. The exact reason/s for the rotation was not determined by this investigation due to the limited evidence supplied. However, the most probable causes, thereto, could be the under-torque of the bolt, wear/collapse of one or more of the washers, damages to the fork itself and/or incorrect assembly.*

1.17. Organisational and Management Information

1.17.1 The aircraft is owned by the operator with an Aircraft Operating Certificate (AOC) issued by the Regulator under the provisions of Part 127 of the CAR 2011 as amended. The AOC was issued by the Regulator on 29 January 2021 with an expiry date of 31 January 2022. The helicopter type was endorsed on the AOC's operation specification. The helicopter was issued a Certificate of Registration by the Regulator on 8 March 2017.

1.17.2 The AMO that conducted maintenance on the helicopter had an AMO-approval certificate issued by the Regulator on 9 March 2021 with an expiry date of 8 March 2022.

1.17.3 The Regulator issued the Certificate of Airworthiness (C of A) for currency renewal of the helicopter without ensuring that all the manufacturer-released SBs, ADs, etc. were adhered to by both the operator and the AMO. The Airworthiness Directive (AD) Schedule released in March 2018, the DCA/HU269/74, requires modification of a fork hinge bolt assembly and accomplish torque checks per Hughes SIN N-155.2 Part I & II, respectively, within the next 100-hour time in service (TIS). The torque checks were also to be conducted at 25-hour TIS following modification and, thereafter, at intervals not exceeding 300-hour TIS.

1.18. Additional Information

1.18.1. None.

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 serious incident. This shall not be read as apportioning blame or liability to any organisation or individual.

2.2. Analysis

2.2.1 The pilot was qualified for the flight. He had a Commercial Pilot Licence (Helicopter) initially issued by the Regulator on 4 June 2001. The pilot's licence was re-issued by the Regulator following a currency revalidation on 25 January 2021 with an expiry date of 31 January 2022. The pilot's Class 1 medical certificate was valid, issued by the Regulator on 29 June 2021 with an expiry date of 30 June 2022.

2.2.2 The helicopter had a Certificate of Airworthiness (C of A) issued by the Regulator on 23 September 2021 with an expiry date of 31 August 2022. The AMO that conducted maintenance on the helicopter issued the Certificate of Release to Service on 3 August 2021 at 724 airframe hours with an expiry date of 2 August 2022 or at 824 airframe hours, whichever occurs first. The AMO had an AMO-approval certificate issued by the Regulator on 9 March 2021 with an expiry date of 8 March 2022.

2.2.3 According to the available records, the bolt was changed following the release of the SB and was incorporated on the helicopter by the manufacturer. This was also confirmed by the AMO upon acceptance for the follow-up maintenance as the bolt with the correct serial number was found. The 25-hour operation torque checks were recommended initially for the helicopter's fork hinge bolt as per the SB. In March 2018, a release of DCA/HU269/74 by FAA re-emphasised that the fork hinge bolt torque checks be conducted at 25-hour TIS following modification and, thereafter, at intervals not exceeding 300 hours TIS. The helicopter was at approximately 240.8 airframe hours at the time of the release of the AD and had operated approximately 543.3 airframe hours at the time of the incident. There were no post-maintenance records indicating that the torque checks inspections of the fork hinge bolt were carried out as per the required intervals post the AD's release.

2.2.4 According to the metallurgical test, the fork hinge bolt failure was due to fatigue fracture mode that initiated in the shank section of the hinge bolt. There was also an indication of rotation within the assembly during operation, which resulted in localised surface damages (stress raisers) and which, in turn, contributed to the initiation of the fatigue fracture. It is likely that several causes, such as under-torque of the bolt, wear/collapse of one or more washers, damages to the fork itself or incorrect assembly during maintenance, might have contributed to this incident, due to insufficient evidence submitted for testing. The helicopter had 784 operating hours since new at the time of the incident. It is the investigation's conclusion that the required torque checks were never conducted.

2.2.5 The Regulator issued the C of A without ensuring that AD DCA/HU269/74 which requires that the AMO conducts the torque test following the 25-hour TIS of the bolt replacement and at intervals not exceeding 300-hour TIS was adhered to. The CRS issued on 3 August 2021 was invalid as the maintenance organisation/engineer did not comply with the necessary FAA ADs for torque check per Hughes SIN N-155.2 Part I & II since March 2018.

2.2.6 The C of A was invalid as the AD was never adhered to by the AMO, thus, the non-adherence thereof resulted in the failure of the bolt which led to this incident. The SACAA did not verify if all the manufacturer's released SBs, ADs, etc. were incorporated before the issuance of the C of A.

2.2.7 Good weather conditions prevailed at the time of the incident. The weather was not an attribute to this incident.

2.2.8 There was enough fuel on-board the helicopter at the time of the flight. Fuel cannot be attributed as the cause of this incident.

3. CONCLUSION

3.1. General

From the available evidence, the following findings, causes and contributing factors were made with respect to this serious incident. 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 Serious Incident. The findings are significant steps in this Serious Incident sequence, but they are not always causal or indicate deficiencies.
- **Causes —** are actions, omissions, events, conditions, or a combination thereof, which led to this Serious Incident.
- **Contributing factors —** are actions, omissions, events, conditions, or a combination thereof, which, if eliminated, avoided or absent, would have reduced the probability of the Serious Incident occurring, or would have mitigated the severity of the consequences of the Serious Incident. 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 pilot was qualified and licensed for the flight. He had a Commercial Pilot Licence (Helicopter) issued by the Regulator on 25 January 2021 with an expiry date of 31 January 2022.

3.2.2 The pilot's Class 1 medical certificate was valid, issued by the Regulator on 29 June 2021 with an expiry date of 30 June 2022.

3.2.3 The helicopter had a Certificate of Airworthiness, issued by the Regulator on 23 September 2021 with an expiry date of 31 August 2022.

3.2.4 The AMO that conducted maintenance on the helicopter issued a Certificate of Release to Service (CRS) on 3 August 2021 at 724 airframe hours with an expiry date of 2 August 2022 or at 824 airframe hours, whichever occurs first.

3.2.5 The aircraft is owned by the operator with an AOC that was issued by the Regulator under the provisions of Part 127 of the CAR 2011 as amended.

3.2.6 The AOC was issued by the Regulator on 21 January 2021 with an expiry date of 31 January 2022. The helicopter type was endorsed on the AOC's operation specification.

3.2.7 The manufacturer released the Service Bulletin B-269.1* on 26 December 2002 which recommended the replacement of the older 269A6092 BSC or 369A1602 BSC fork hinge bolt with the 269A6092-3 bolt, as well as clarifying the torque specification of the fork bolt.

3.2.8 The helicopter's fork hinge bolt failed during operation, causing server vibration and the subsequent damages to the tail rotor boom and stabiliser. According to the AMO, the failed fork hinge bolt was the recommended bolt as per part number 269A6092-3, which was replaced following the release of the Service Bulletin B-269.1* by the manufacturer. There were no maintenance inspection recordings indicated as per the required intervals not exceeding 300 hours following the 25-hour torque checks after the initial modification.

3.2.9 According to the available records, the bolt part number was also confirmed during a follow-up maintenance after the release of the SB. According to the metallurgical test, the fork hinge bolt failure was due to fatigue fracture mode that initiated in the shank section of the hinge bolt. The bolt was weakened overtime time during operation.

3.2.10 The helicopter had 784 hours since new at the time of the incident. The FAA released an AD for torque check as per Hughes SIN N-155.2 Part I & II, in March 2018. Following the release of the AD, all maintenance carried out on the helicopter did not include records of adherence to the AD. Therefore, the CRS issued for ZS-HEW on 3 August 2021 was rendered invalid as the maintenance organisation/engineer did not comply with the manufacturer-released AD which could have prevented this incident.

3.2.11 The SACAA issued the C of A without verifying if the SBs and ADs released by the helicopter manufacturer were adhered to by the AMO.

3.3 Probable Cause

3.3.1 The helicopter fork hinge bolt failed on the bolt head due to a fatigue fracture which initiated in the shank section of the hinge bolt and progressed overtime, causing the imbalance in the tail rotor which resulted in the pilot executing an autorotation landing.

3.4 Contributory Factors

3.4.1 It is likely that several causes, such as under-torque of the bolt, wear/collapse of one or more washers, damages to the fork itself or incorrect assembly during maintenance, might have contributed to this incident. Due to insufficient evidence submitted for testing, the cause could not be proven.

3.4.2 Improper maintenance due to procedure that was not followed for the fork hinge bolt inspection torque checks during intervals not exceeding 300 hours TIS.

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 None.

5. APPENDICES

5.1. None.

This report is issued by:

Accident and Incident Investigations Division
South African Civil Aviation Authority
Republic of South Africa