

Serious Incident

Aircraft Type and Registration:	Leonardo AW139, G-CIMU	
No & Type of Engines:	2 Pratt & Whitney Canada PT6C-67C turboshaft engines	
Year of Manufacture:	2015 (Serial no: 31583)	
Date & Time (UTC):	13 June 2022 at 1801 hrs	
Location:	Norwich Airport	
Type of Flight:	N/A found during maintenance inspection	
Persons on Board:	Crew - None	Passengers - None
Injuries:	Crew - N/A	Passengers - N/A
Nature of Damage:	Bearing failure	
Commander's Licence:	N/A	
Commander's Age:	N/A	
Commander's Flying Experience:	N/A	
Information Source:	AAIB Field Investigation	

Synopsis

The failure of an AW139 tail rotor duplex bearing was identified during a post-flight maintenance check from wear damage on the bearing/actuator cover. The extent of the damage to the bearing confirmed that a loss of tail rotor control event would likely have occurred had the helicopter continued to operate with the bearing fitted. The bearing is defined as a critical part and failure of a similar design of bearing fitted to an AW169 helicopter resulted in a fatal accident in 2018. Despite a full forensic assessment, the bearing was too badly damaged to determine the cause of failure. Three Safety Recommendations have been made to address safety concerns relating to the failure of tail rotor duplex bearings on the AW139.

Initial report of a bearing failure

The helicopter had operated a passenger flight to North Sea oil rigs during the day. On its return it was moved into the hangar to perform a daily maintenance inspection. During the walkaround check, the maintenance team noticed that a hole had been worn in the cover mounted over the tail rotor duplex bearing and the end of the tail rotor control actuator. Removal of the cover confirmed the presence of a large amount of carbon dust on the inside. The actuator was protruding further than normal; the bearing race was badly damaged and the ball bearings in the outboard race of the bearing were visible (Figure 1).



Figure 1

Bearing cover, and damaged tail rotor bearing in situ

The maintenance team tried to remove the bearing, but the damage was so severe that the bearing disintegrated into its component parts during this process.

The AAIB was informed of the incident by the operator and, given its possible relevance to another ongoing bearing failure investigation¹ on the AW169 and AW189 helicopter types, an investigation was launched. The AAIB attended the operator's maintenance facility to review the removed bearing and actuator, which were then recovered for independent analysis.

Aircraft description

The Leonardo AW139 was the first of three models from the same family type to be introduced, the others being the AW169 and AW189. Each model varies in size but shares similar design features and components. The AW139 formally started development in March 1999 and was granted a type design by ENAC² in June 2003. The subsequent European Union Aviation Safety Agency (EASA) type certification approval date was September 2003. The AW139 has a certified MTOW of 6,400 kg, which can be increased to either 6,800 or 7,000 kg when the helicopter is operated in accordance with the relevant Rotorcraft Flight Manual (RFM) supplement, and the appropriate mod kit is embodied. It has an operating ceiling of 20,000 ft.

Description of helicopter yaw control system

Helicopters can manoeuvre in three axes: pitch, roll and yaw. Yaw is rotation around the vertical axis and changes the heading of the helicopter. Movement about this axis is controlled by a set of opposing foot pedals, which change the tail rotor blade pitch. Pressing the right pedal forward pushes the left pedal back and rotates the nose to the right, pressing the left pedal forward, pushes the right pedal back and rotates the nose to the left, (Figure 2).

Footnote

¹ See report section 'Other information'.

² Ente Nazionale per l'Aviazione Civile – Italian national airworthiness authority.

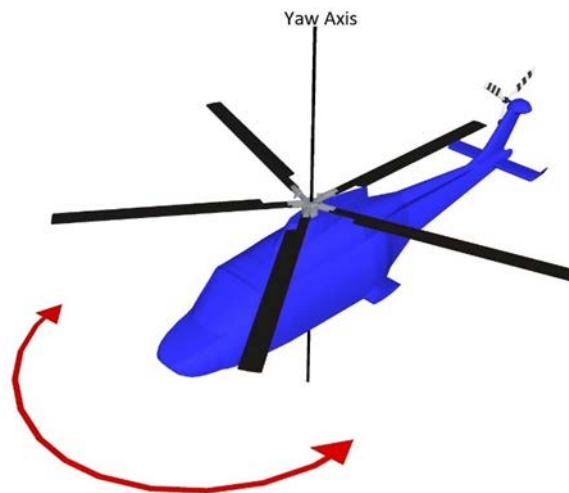


Figure 2
Helicopter yaw axis

In helicopters such as the AW139, with a single main rotor system that turns anti-clockwise (looking down from above), a torque couple is created when the rotor blades rotate under power from the engines, this causes the nose of the helicopter to yaw to the right. To resist this tendency, for example when the pilot wishes to keep the helicopter straight or to yaw to the left, a smaller rotor system is fitted to the tail of the helicopter.

This tail rotor generates a torque around the yaw axis which can match the torque couple from the main rotor, thus keeping the helicopter pointing forward or if required exceed it, resulting in the helicopter yawing to the left. The tail rotor blades rotate at a relatively constant speed. To increase or decrease the force generated by the tail rotor system, the angle at which the rotor blades travel through the air relative to their path of rotation (pitch), is adjusted on all the blades at the same time. Increasing the angle increases the force, reducing the angle reduces the force. The control input load required to change the angle of the blades on large helicopters such as the AW139, is too large for a pilot to achieve by moving a simple direct mechanical linkage. A hydraulic system is therefore used to translate the pilot's control inputs on the pedals into changes in the tail rotor blade pitch angle.

Adjustment of the tail rotor blade pitch is achieved by a tail rotor control actuator. The control shaft of the actuator extends and retracts in response to the movement of hydraulic fluid on either side of a set of pistons, in response to the pilot's pedal inputs. The input from the pedals is via an input lever which is attached to the end of the actuator shaft by a castellated locking nut. On the AW139 this nut has a left-hand thread. This ensures that if the actuator shaft rotates due to a failure of the system, the nut will tighten, and the input lever will remain connected to the actuator.

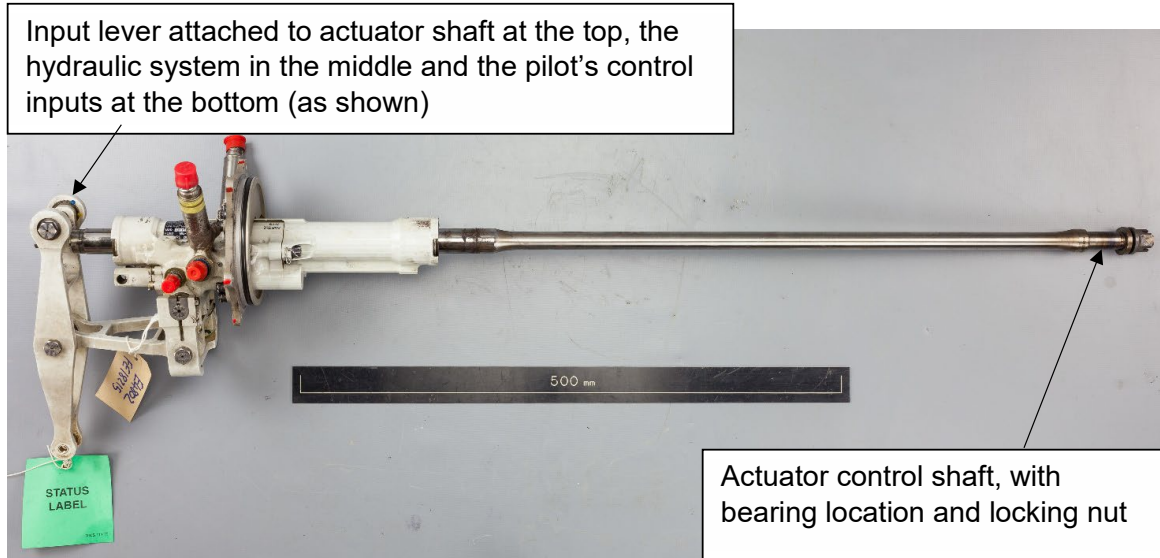


Figure 3

AW139 Tail rotor control actuator

The actuator is attached to the tail rotor gearbox and the control shaft passes through the gearbox located within a hollow drive shaft. The tail rotor head is attached to and is driven by this gearbox drive shaft. The static actuator control shaft connects to the rotating components of the tail rotor by means of a duplex bearing. Figure 3 shows the pilot input mechanism on the left side of the actuator and the location of the duplex bearing and securing nut on the right-hand end of the control shaft (as orientated in the image).

The inner race of the bearing is fitted to the control shaft and is locked in place by a securing nut, while the outer race rotates with the tail rotor hub. A smaller hub called the spider is attached to the tail rotor hub by scissor links and locates a slider which supports the outer race of the duplex bearing. The slider guides the movement of the spider as it is extended and retracted by the action of the control shaft. Each of the arms of the spider is connected by a rod (pitch link) to the rear of a tail rotor blade (Figure 4).

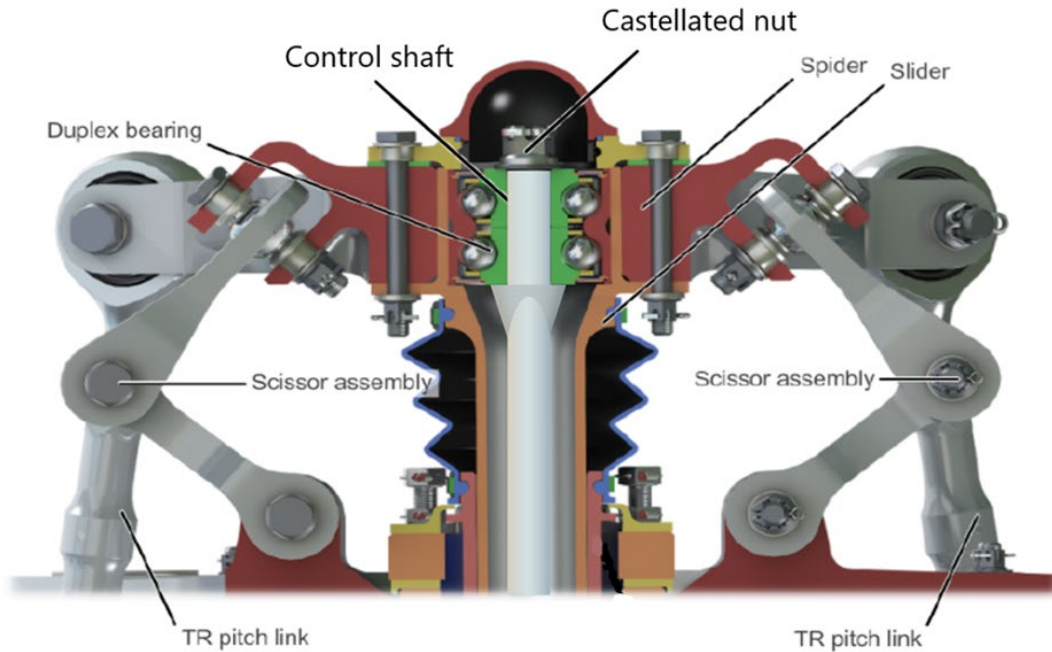


Figure 4

Tail rotor spider and pitch link assembly
(Original image courtesy of the manufacturer)

As the control shaft moves in two directions (extend/retract), the bearing is required to have two rows positioned back-to-back to support the axial load in each direction. In order to support loads in both the axial (F_z) and radial (F_y) directions, the running surfaces of each row are angled at approximately 30° . The control shaft also experiences a bending moment (M) which is transferred to the bearing (Figure 5).

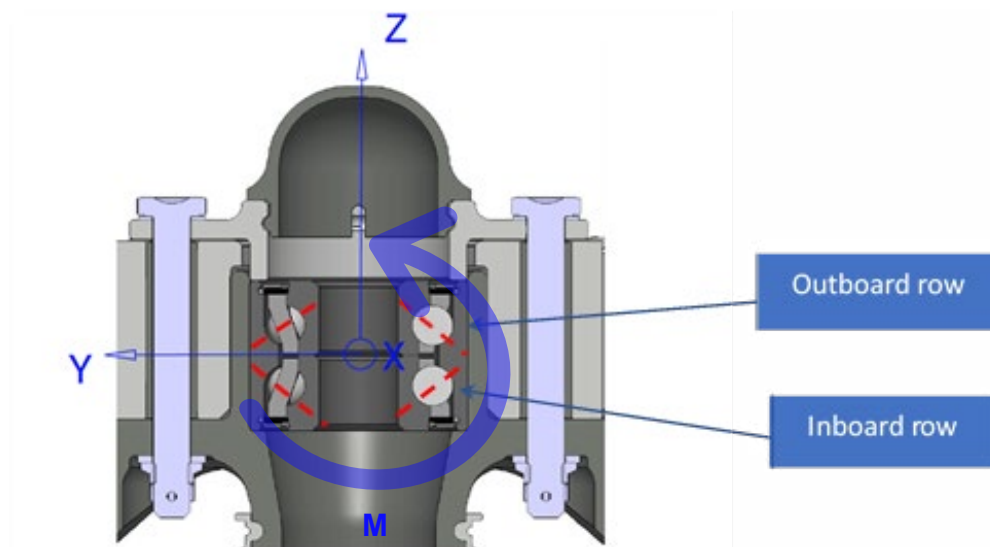


Figure 5

Diagram (with control shaft removed) showing two halves of the bearing (inboard and outboard) and the 30° orientation
(Original image courtesy of the manufacturer)

The two halves of the bearing are referred to as the inboard and outboard rows based on their relative position to the helicopter centreline. The inner races are clamped together on the control shaft by the castellated nut. The internal design of the bearing in combination with the torque setting on the nut ensures the correct preload is applied to the bearing. The correct preload gives a consistent baseline contact pressure which is necessary so that the ball bearings roll rather than skid along the running surfaces. By applying a constant installed load, it also reduces the amount of deflection within the bearing when external operational loads are applied.

The bearing consists of a steel one-piece outer housing, which forms the two outer races (running surfaces) of each half of the bearing, two steel inner races, two sets of nine silicon nitride ceramic ball bearings and two bronze alloy cages. The cages sit between the inner and outer races of the bearing to locate the ball bearings, ensuring the balls are in contact with the races in the correct position. An elastomeric seal on each end of the bearing prevents entry of contaminants and debris.

The bearing drawing was amended in 2021 from requiring 100% grease fill to specifying a minimum 33% fill, which equates to 2 g of grease in total.



Figure 6

Bearing in new condition - (A) Housing and outer race, (B) inner race, cage and balls assembled, (C) cage, seal and inner race disassembled

Figure 6 shows the housing and the outboard row, outer race in image A. Image B shows the inner race, cage and balls as they have been removed from the housing in image A and turned over (the top surface in view is normally located in the middle of the bearing). Image C shows the inner race, cage and seal after they have been disassembled and the balls removed. The other row of the bearing is identical but is installed the opposite way around (mirror image).

The combination of steel races with ceramic ball bearings is referred to as a hybrid bearing. Use of ceramic ball bearings provides several benefits over traditional all steel bearings. These include weight reduction, a wider operating temperature range, allowing higher rotational speeds, better resistance to corrosion and they are electrically isolating. However, as the silicon nitride material is exceptionally hard, it is also more brittle and can be susceptible to shock loads. The relative hardness of the ceramic ball compared to a steel ball bearing also reduces the contact area with the races, resulting in approximately 12% higher contact pressure³ applied to the race material under the same load.

The tail rotor duplex bearing is classed as a critical part. Critical parts are defined by EASA Certification Specification (CS) 29.602 as:

'A critical part is a part, the failure of which could have a catastrophic effect upon the rotorcraft, and for which critical characteristics have been identified which must be controlled to ensure the required level of integrity.'

Tail rotor duplex bearing development history

Hybrid bearings have been used in various industry applications for around 40 years but are less common in aerospace applications, particularly in critical safety functions.

The helicopter manufacturer first introduced a hybrid duplex bearing design on the AW139 tail rotor control system as part number (p/n) 3G6430V00151. This was subsequently modified in 2006 by a minor modification to facilitate assembly, which changed the p/n to 3G6430V00153. The bearing is manufactured and delivered as a sealed unit by the bearing manufacturer and is then assembled onto the tail rotor actuator control shaft by the helicopter manufacturer. The AW139 bearing has accumulated 4,690,742⁴ hours in-service across both part numbers.

Dimensionally and functionally, the p/n 3G6430V00153 bearing is identical to the bearing which was subsequently used in the AW169 and AW189 tail rotor system. The steel specification for the race material is 100C6. This was changed to CHROMEX 40 on the AW189/AW169 bearing to address corrosion issues experienced in-service on the AW139 bearing. 100C6 is approximately double the hardness of CHROMEX 40.

Original certification of the bearing on the AW139 considered it to be an 'on condition' part. This meant it had no scheduled removal time and remained operating in-service until it required replacement due to deterioration of its performance.

There were originally two Approved Maintenance Planning Information (AMPI) Manual maintenance tasks required which affected the bearing. The condition of the bearing is assessed by a tactile check of the bearing's rotational smoothness, achieved by

Footnote

³ The figure of 12% is quoted by a number of research papers including: Lorösch, H.K., Vay, J., Weigand, R., Gugel, E., Kessel, H., (1980). Fatigue Strength of silicon nitride for high-speed rolling bearings, Transactions of ASME, J. of Engineering for Power, vol. 102, 128-131.), A figure of 12.8% is also quoted by NASA paper NASA/TM-2005-213061.

⁴ As of October 2025.

disconnecting the spider from the rotor blades and rotating it by hand. This check was scheduled every 600 flying hours or one calendar year, whichever came first. At 2,400 flying hours or four calendar years the bearing was removed from the slider, and the spider/slider assembly visually inspected, before the bearing was refitted. If bearings were rejected due to roughness during these routine maintenance checks, they were disposed of by the operator and a new bearing fitted. Data provided to the investigation from a retrospective assessment of UK and Italian AW139 operators' records by the UK and EU airworthiness authorities confirmed that a number of bearings were rejected across a range of operating hours for roughness, axial play and grease leakage, as a result of these inspections.

2012 AW139 bearing serious incident

In 2012, an operator based in Qatar suffered a loss of yaw control incident on an AW139. This was found to have been caused by a failure of the duplex bearing (p/n 3G6430V00151) at 4,117 flight hours since new. Evidence of rotation of the tail rotor actuator control shaft confirmed that the bearing had seized at some point. However, as the control shaft had a left-hand thread, the pin carrier had tightened onto the actuator shaft, rather than unscrewing⁵. This transferred the torque load back into the bearing, forcing rotation until the bearing components became so heavily worn that the bearing failed completely, to the extent that it no longer provided any resistance to the movement of the hydraulic actuator. Effectively no longer attached to the control system, the tail rotor blades moved to, and remained at, a positive blade pitch angle of approximately 10° with no means of changing the blade position possible by pilot action. The helicopter started to turn under the influence of the main rotor torque couple, but the loss of tail rotor control occurred while the helicopter was in forward flight. The reduced engine torque demand, the vertical tail surface aerodynamically contributing to the yaw control and the force generated by the default blade position, were sufficient to allow the pilot to maintain forward flight and perform a 'run on' landing without any additional damage occurring to the helicopter.

The 2012 AW139 loss of yaw control event wasn't subject to an independent Annex 13 investigation, and the operator, helicopter manufacturer and local airworthiness authority assessed that the bearing was too badly damaged to conduct a meaningful failure analysis.

As a precautionary response to the bearing failure, the manufacturer applied two new requirements to the AW139 bearing. The first was an amendment to the Approved Maintenance Manual (AMM) stating bearings shall not be refitted after removal from the spider/slider assembly. The second was to apply a discard life of 3,000 hours. Once a bearing reached this life in-service it was discarded by the operator and a new bearing fitted. This change was introduced in August 2012 by a Mandatory Service Bulletin (SB) 139-288 from the manufacturer. For bearings over 3,000 hours this required a check for roughness in rotation of the bearing every 200 hours, until the bearings were replaced within a maximum period of six months. The airworthiness authority did not issue an Airworthiness Directive to mandate this action, as such the discard life was only controlled by an amendment to Chapter Five of the AMPI.

Footnote

⁵ See report section '*AW169 bearing failure investigation*' for further information.

A selection of seven bearings across a range of service lives from 98 to 7,000 hours were removed and sent back to the bearing manufacturer for assessment of their condition. No abnormal wear was identified. The bearing manufacturer's stated conclusion from this assessment was that they supported a discard life of 2,400 hours (rather than 3,000 hours), in addition to the 600 hour rotational inspections.

Initial investigation of the G-CIMU failed bearing

The operator reviewed their maintenance records for the failed bearing from this event. The bearing was installed new in 2018. The records confirmed that the spider/slider assembly had been replaced in 2020, following a 2,400 hour required inspection, but the duplex bearing had been refitted to the replacement spider/slider rather than being disposed of, which was contrary to the AMM instructions. The bearing had accumulated 1,007 flight hours since new, when it was refitted. When the bearing's failure was identified its total operating hours were 2,750, indicating it had operated a further 1,743 hours since being refitted. Review of the operator's fleet identified seven other bearings which had also been refitted contrary to the AMM instructions. These bearings were also removed from service and retained by the investigation. The additional bearings were disassembled and inspected, but no damage was identified.

The duplex bearing is fitted in the slider/spider assembly and held in place by means of an interference fit. Removal of the bearing to facilitate a maintenance inspection of the slider, requires the use of an Arbor press applying force to a tool in contact with the inner race to push the bearing out of the slider housing. This results in the force applied by the press being transferred through the balls to the outer race. The manufacturer considered that this would result in brinelling⁶ damage on the bearing races, leading to the failure of the bearing if it was then refitted and returned to service. However, prior to the prohibition on refitting bearings after the 2012 incident, this extraction technique had been used for more than seven years to remove bearings on a routine basis, prior to the refitting and return to service of these bearings, without significant numbers of in-service failures.

Both the investigation and an audit by the UK regulator of the operator's maintenance procedures, identified that the maintenance process used to refit all the tail rotor duplex bearings at the operator's facility didn't comply with the AMM procedure. Due to the interference fit between the bearing outer race and the slider in which it was located, the AMM procedure required the bearing to be cooled prior to it being refitted to the slider. The operator was using an unapproved technique to cool the bearings which resulted in them being cooled to a significantly lower temperature than stated by the AMM. The grease manufacturer was consulted by the investigation to determine whether this may have been a factor in the deterioration of the failed bearing in-service. They confirmed that the temperature achieved by the incorrect process used was likely still within the specification of the grease and once the bearing had returned to ambient temperature, there would be no ongoing adverse effect. This assessment was validated by the lack of damage identified on the other bearings which had been subject to this technique and had also been refitted and returned to service.

Footnote

⁶ A type of plastic deformation caused by repeated, localized impacts or static overload, brinelling causes surface damage to a bearing raceway in the form of regularly spaced indentions.

Manufacturer and Airworthiness Authority's immediate response

A Technical Information Letter (22-004) was issued in June 2022 reminding operators that the tail rotor duplex bearings fitted to AW169, AW139 and AW189 should not be refitted after removal, in accordance with the AMM. This was immediately followed by Temporary Maintenance Instruction 139-559 to amend the applicable AMM task to further clarify this requirement. The helicopter manufacturer then issued an Emergency Alert SB 139-725 in July 2022. This reduced the bearing discard life to 2,400 hours to bring it in line with the maintenance inspection requirement that required the bearing to be removed, addressing any ambiguity about whether it could be refitted. A short interval repetitive inspection programme was introduced on bearings with a life greater than 2,400 hours or that had been refitted, until those bearing were removed from service in accordance with the SB requirements. It also required a slippage mark to be applied to the actuator to identify any rotation of the control shaft, which would be indicative of the duplex bearing seizing. While not the stated reason for the change, this also aligned the AW139 bearing life with the bearing manufacturer's recommended discard life for the AW169/AW189 bearings.

EASA then issued Airworthiness Directive (AD) No. 2022-0182-E, which mandated the removal from service of bearings over 2,390⁷ hours.

While the SB and AD were necessary to correct an airworthiness discrepancy across the global fleet, it was also based on the helicopter manufacturer and EASA's assessment that refitting of the bearing was likely to be the cause of the bearing failure.

G-CIMU bearing failure investigation

The failed bearing removed from G-CIMU was sent by the investigation to an independent, specialist forensic metallurgy organisation who conducted a detailed analysis of the component parts of the bearing.

Inner races

Both inner races were heavily worn and distorted (Figure 7). Some damage had also occurred when the operator was removing the damaged bearing from the control shaft using pliers (Figure 7). The race surfaces showed evidence of cracking and material deposition, notably copper from the cages. This layer of deposited material was approximately 10 µm thick on the inner race, but areas up to 25 µm were also observed.

Hardness testing of the inboard inner race material, resulted in hardness measurements approximately half to a third of the specified value for a new race. Etching of cross-sectional samples of the race material showed evidence of microstructural change due to heating.

Footnote

⁷ The AD allows 10 hours for implementation, giving a total limit of 2,400 hours.

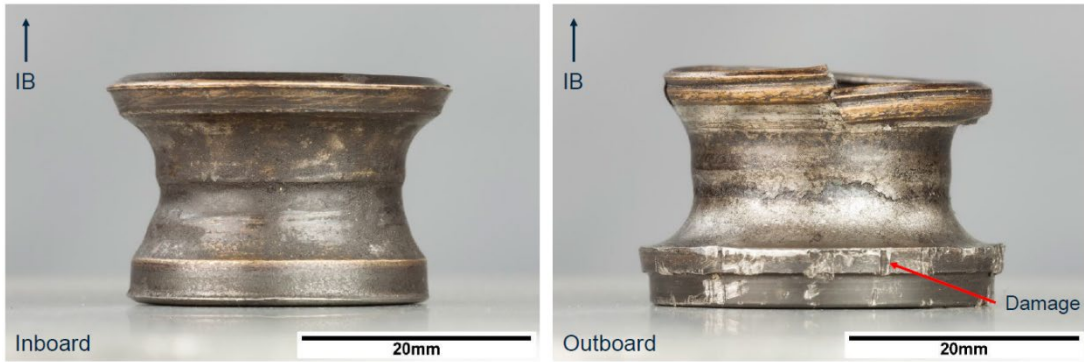


Figure 7

Inboard and outboard inner races

Outer race

This was also heavily distorted compared to the standard race profile for the bearing.

Cross sections of both inner races and the outer race in Figure 8 show the severe level of damage and distortion.

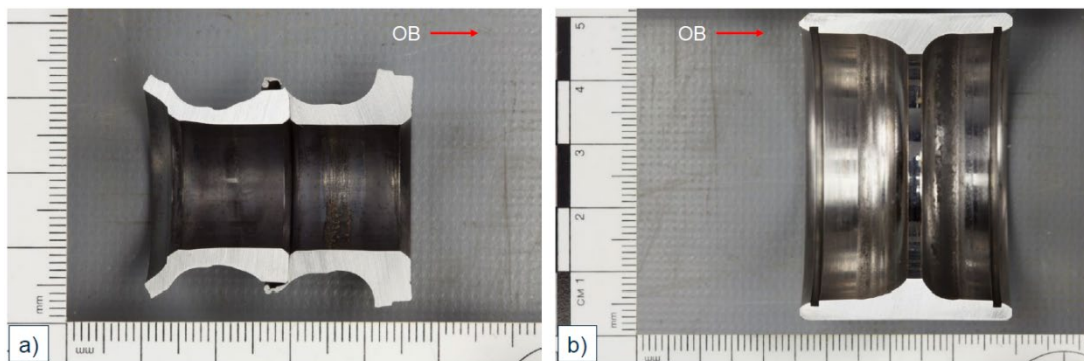


Figure 8

Cross section of the inner and outer races

These damaged cross sections were superimposed on the original design cross section to highlight the changes (Figure 9). The yellow hatched sections are the damaged bearing races; the teal coloured sections are the intended design cross section, showing the extent of the missing and deformed material.

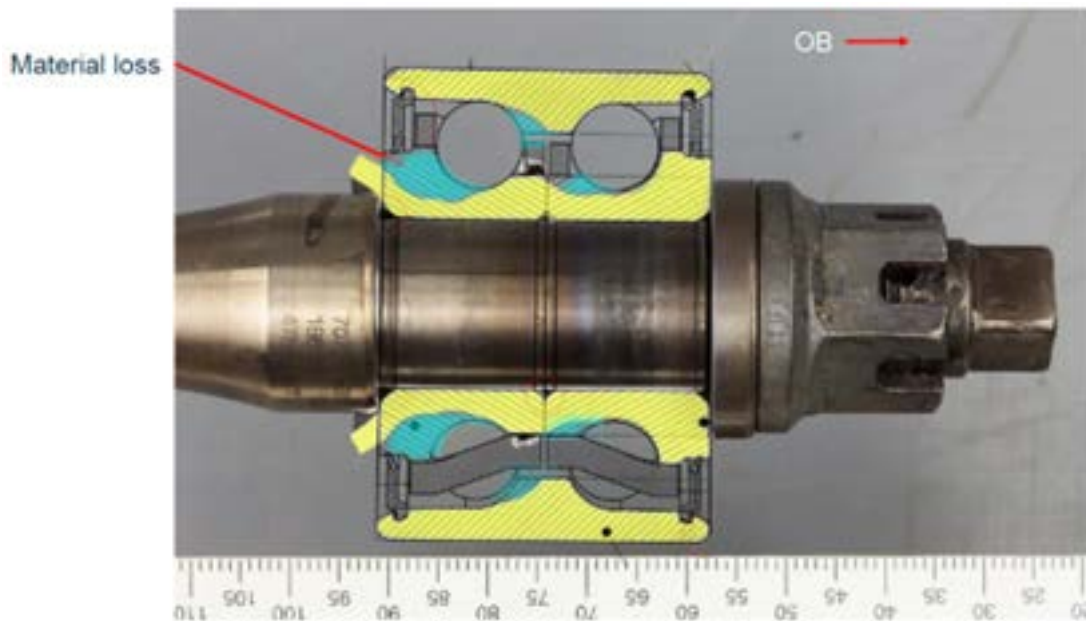


Figure 9

Failed bearing cross section (yellow) compared to a new bearing (teal)

Cages

One of the cages had fractured into two pieces. The other cage was heavily worn and fragmented. The fracture surfaces were too heavily damaged to assess the failure mechanism reliably (Figure 10).



Figure 10

Recovered cage fragments: a) cage failed in two pieces, b - e) heavily worn fragments of the second cage

Balls

Assessment of the balls identified surface deposits consistent with wear material from the cages and races. The surface of one of the balls displayed damage marks indicative of sliding rather than rolling (Figure 11).

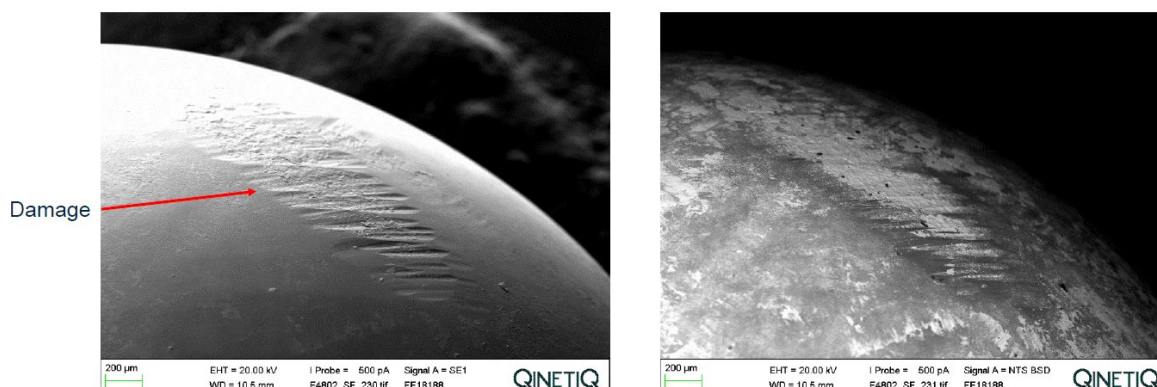


Figure 11

Damage marks on a ball, indicative of sliding rather than rolling

The dimensions of the balls were measured and found to be mostly below the specified diameter. The ball sizes are selected to tight tolerances at manufacture to avoid significant variation across each set of nine balls within a race. The range of measurements recorded suggested that half the balls had worn evenly and still had similar diameters within 1 µm of each other, while the other half had worn unevenly, with between 17-60 µm variation in diameter. It is likely these heavily worn balls were all fitted within the same race.

Recorded information

Health and Usage Monitoring System (HUMS)

The main functions of the HUMS fitted to the AW139 are Transmission Vibration Monitoring (TVM), Usage Monitoring (UM) and Rotor Track and Balance (RTB). UM includes logbook data, Transmission Usage Monitoring (TUM) and Structural Usage Monitoring (SUM).

The system includes 17 accelerometers. The installation can monitor 60 components, 50 on the main gearbox, four on the intermediate gearbox, four on the tail gearbox and two on the tail rotor driveshaft. The monitoring function provides 42 indicators, 14 for gears, 14 for pinions, two for shafts and 12 for transmission bearings. The tail rotor duplex bearing is not subject to vibration monitoring.

SUM data includes the continuous recording of a subset of flight parameters, which includes pedal position and airspeed.

HUMS data is stored in a dedicated PCMCIA memory card installed in the HUMS Cockpit Display Unit in the cockpit inter-seat console.

The operator or maintainer uploads HUMS data to the manufacturer's Heliwise system which processes the data and provides an interface for the customer to review the data. There are different levels of HUMS support available from the manufacturer. This helicopter was under a Premium level analysis contract. Under this scheme the operator is responsible for the HUMS data management and analysis (using Heliwise) and the manufacturer's support team is engaged when required.

Recorded information

The helicopter was fitted with a combined CVR and FDR. This recorded 25 hours of data and two hours of crew and cockpit area audio. The operator provided current HUMS data for the helicopter, and the helicopter manufacturer also provided historical HUMS data sets.

The bearing issue was found during maintenance after a flight. The flight was from Norwich to a series of rigs in the North Sea, north-east of Norwich. Seven rig landings were flown before returning to Norwich. During one of the legs flown between rigs the CVR recorded the pilot monitoring saying, "I'M JUST THINKING ABOUT THE PEDALS, THEY ALL SEEM A BITS STRANGE TO ME, LIKE WHEN I WAS FLYING IT, ONE SEEMS FURTHER FORWARD THAN THE OTHER." This was a passing, isolated comment and did not appear to be of great concern to the crew.

Operator HUMS review

The operator stated that they had reviewed the HUMS data, as per their normal practice, and not found anything relevant flagged by the system.

Manufacturer HUMS analysis report

The manufacturer was asked to analyse the HUMS data in relation to the investigation. They generated Technical Note: DSE-2022-002 revision A, dated 23 June 2022, titled 'AW139 31583 – HUMS Analysis Report for TR Duplex Bearing failure'. This provided a basic description of the system, an overview of the data transferred from G-CIMU to Heliwise after the event on 13 June 2022, and a focused review of the data relating to the tail rotor.

Heliwise did not trigger any arisings from the data transferred after the failure was found. The previous arising was recorded against the data transferred on 7 June 2022 and related to a single spurious main rotor track and balance acquisition value.

The report documented a routine maintenance activity summary supplied by the operator to the manufacturer in November 2021 indicating that among other activities, the tail rotor drive shaft bearing support, tail rotor head and tail rotor actuator servo had been removed, inspected and refitted. They requested for the trending analysis to be reset due to the changes.

The data analysis overview of the report stated:

'The TVM and RTB data related to the TGB and TR have shown a stable trend in the last 200 FH, which is the time frame of data viewable live on Heliwise. Data is not showing rising or concerning trend. The only HI slightly above the fleet average is the index FSA_S0002 or TVM SYNC Acquisition 039 – Tail Gearbox, which measures the level of 2 per revolution of the TR mast.

An increase of FSA_002 values in case of maintenance activities on the TR, which includes the replacement of TR components, are quite common due to the change of the rotor balance. In some cases, the TR tuning can lead to

an optimisation of the 1xRev but a worsening of the 2xRev, as the algorithm calculating the corrections to be applied is designed to optimize the 1xRev...'

The report concludes:

'The analysis discussed above puts in evidence that the TVM signals acquired with the current TGB TVM sensor do not allow to highlight the TR duplex bearing failure occurred. The AW139, unlike the AW169 and AW189, does not have a dedicated sensor to monitor the tail rotor duplex bearing gearings. The TVM sensor A09 seems not allowing the properly monitor of the TR DB.

The 2xRev, recorded the RTB and TVM SYNC acquisitions, even if slightly above the limit, increased due to the maintenance activities. Similar issues have been managed multiple times by the LHD HUMS Support Team, as discussed in paragraph 3.1. Due to this, it not possible to correlated an imbalance of the TR head configuration with the TR duplex bearing failure.'

AAIB review of trends associated with pedal position at speed

Prompted by the extent of bearing damage observed and comments captured by the cockpit voice recording during the prior flight, a further review of the pedal position behaviour was carried out by the investigation. This used the SUM data captured by HUMS using a method that is not part of the normal Heliwise monitoring mechanism.

With a serviceable duplex bearing providing a fixed relationship between the pedal position and the tail rotor blade pitch, the average pedal position while cruising at high speed should be approximately stable. The level of damage observed on the tail rotor bearing would have varied this relationship, resulting in a change in the pedal position required to achieve a required tail rotor thrust.

Historical Heliwise data that captured pedal positions during flights was obtained for G-CIMU. This covered nearly 900 flights, 400 flight hours, from early January 2022 the date of the discovery of the failed bearing.

Each flight was filtered to capture periods when the helicopter was flying between 145 and 150 KTAS. If more than 100 seconds of flight was found, the average pedal position was calculated for that period. Figure 12 shows the pedal position data, in recorded units. A changing trend in the relationship between airspeed and average pedal position is apparent starting from approximately 7 June 2022. This is approximately 15 flight hours before the failed bearing was discovered.

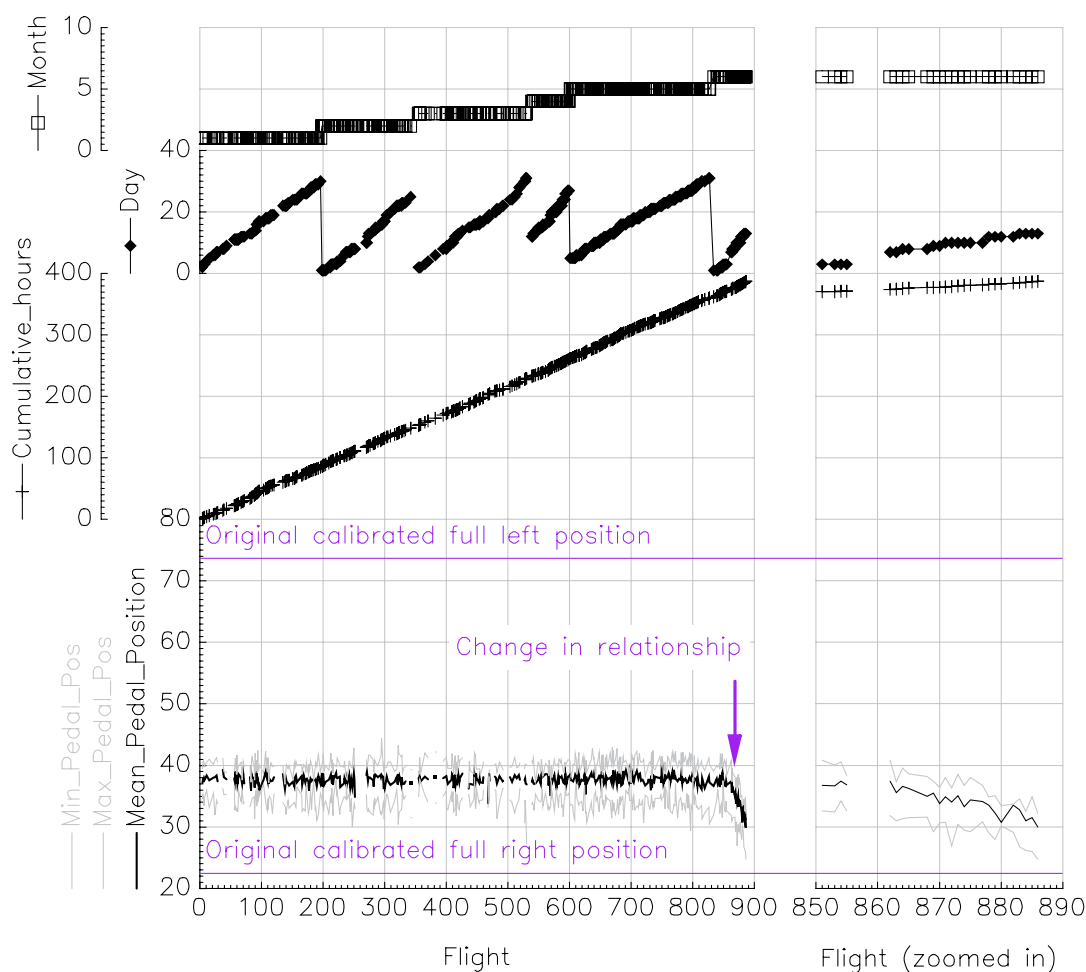


Figure 12

Average pedal position when flying between 145 KTAS and 150 KTAS for more than 100 seconds

A similar data review of four other helicopters, without bearing issues, was carried out to establish whether the variation in pedal position observed in the event helicopter before the observed change in pedal position, was normal. This showed similar variation around a relatively stable mean pedal position, albeit with different stable values reflecting variations in rigging/sensing of the pedal position.

Tests and research

In issuing the initial response SB and AD following the finding of the G-CIMU failed bearing, the helicopter manufacturer and EASA assessed that the likely cause of the bearing failure was brinelling damage to the bearing races during extraction of the bearing. However, the investigation could not identify any empirical evidence to support this finding, and a request was made to conduct a rig test to assess whether the postulated damage to the bearing races could be replicated in test conditions.

The test was conducted by the helicopter manufacturer using a hydraulic test rig which applied a measured force to the bearing inner race, until the bearing released from the

slider housing. The test was conducted with the components at ambient temperature (between 18 and 28 °C). The test bearing and slider were specifically manufactured to the worst case tolerances providing the highest level of interference fit possible (0.025 mm) and the minimum amount of grease (1 g) was used in each side of the bearing. The extraction tool was also offset from perpendicular with the bearing face by 0.9° to increase the applied force on one side, replicating possible maintenance issues. The static limit load in the axial direction (F_z) quoted by the manufacturer's development load spectrum for the AW139 duplex bearing was 12,470 N. During the test the axial (F_z) load was progressively increased until the bearing released from the slider at a measured applied load of 18,894 N. The bearing also suffered a significant impact force after it released, as it unintentionally struck the end of the test rig (Figure 13).

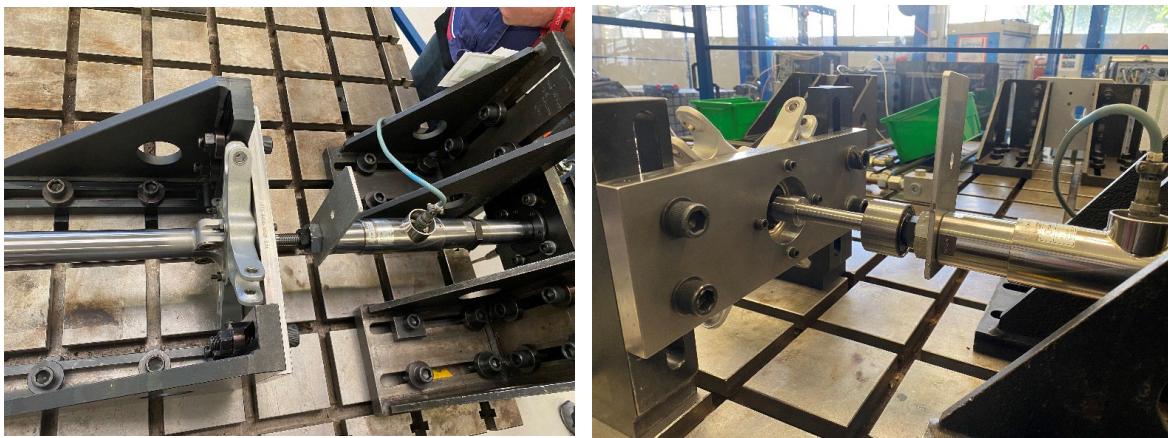


Figure 13

Test bearing before and after it released from the slider/spider assembly

Following removal from the test rig, the test bearing was initially X-rayed using a CT scanner, which did not show any evidence of damage to the race surfaces. It was then returned to the bearing manufacturer's facility for disassembly and inspection. The bearing was visually inspected using a microscope and the inner and outer race circumferential profiles were measured at various heights. The bearing manufacturer concluded that no damage was observed and there was no identifiable difference between the pre and post-test inspections of the bearing.

Other information

Service Bulletin 139-728

In October 2022, the helicopter manufacturer issued a second SB (139-728) applicable to AW139 helicopters where the duplex bearing had not been removed and refitted.

Part I of the SB required, within 50 hours or 2 months, the application of a slip mark on the locking nut installed on the input lever end of the tail rotor actuator control shaft. A further inspection for absence of rotation was required after every subsequent 50 hours of operation.

Part II of this SB required visual inspection of the tail rotor duplex bearing to check its external condition for absence of wear particles within any extruded bearing grease, for bearings which had accumulated more than 1,200 hours but had not been removed and refitted. The initial inspection was required within 50 hours or 2 months, with a repeat inspection every 100 hours.

Part III of the SB required inspection of the tail rotor duplex bearing for axial play and roughness in rotation where the bearing had accumulated more than 1,200 hours but had not been removed and refitted. The initial inspection was required within 50 hours or 2 months, with a repeat inspection every 300 hours or 1 year.

To summarise, all helicopters were required to have a slip mark applied on the actuator locking nut, which is inspected every 50 hours, but only bearings with over 1,200 hours accumulated operating time must be inspected for condition on a more frequent basis than required by the AMPI (100 and 300 hours compared to 600 hours).

EASA did not issue an AD to mandate these additional inspections.

G-CKYP

On 17 June 2022 a tail rotor duplex bearing was removed from service after failing an inspection and was sent to the helicopter manufacturer for further investigation. Following disassembly and cleaning, evidence of fatigue was observed on the bearing race. Given the possible significance to the investigation, the bearing was recovered from the manufacturer by the AAIB for further independent investigation. The bearing had accumulated 1,640 hours since new.

The bearing was sent for detailed forensic investigation at a specialist metallurgy lab using a protocol which was developed during the investigation of a failed AW169 tail rotor duplex bearing.

The bearing cages exhibited evidence of wear and some minor scratches but were both intact. The outer race surface for side one exhibited evidence of minor blemishes, likely imprints from rolled over debris, but no evidence of Rolling Contact Fatigue (RCF). However, side two exhibited imprints and surface-breaking RCF, which was confirmed by inspection under high magnification and using a scanning electron microscope. Cross sections of the races were etched and inspected, but there was no evidence of microstructural change and no Dark Etched Region (DER) was present under the surface.

The inner rings also demonstrated the presence of minor debris indentation marks on side one but no RCF. The inner ring from side two exhibited indentation marks and RCF similar to the outer race. Again, there was no evidence of microstructural change or a DER. The location of the damage was also lower than the normal running line of the bearing race, which is where the highest contact pressure usually occurs during in-service operation. In combination with the lack of DER, this suggested the damage may not have resulted exclusively from the operating loads on the bearing. The debris indent marks on the races and scratches on the cage, raised the possibility that contamination may have been present within the bearing leading to the initiation of the surface RCF (Figure 14).

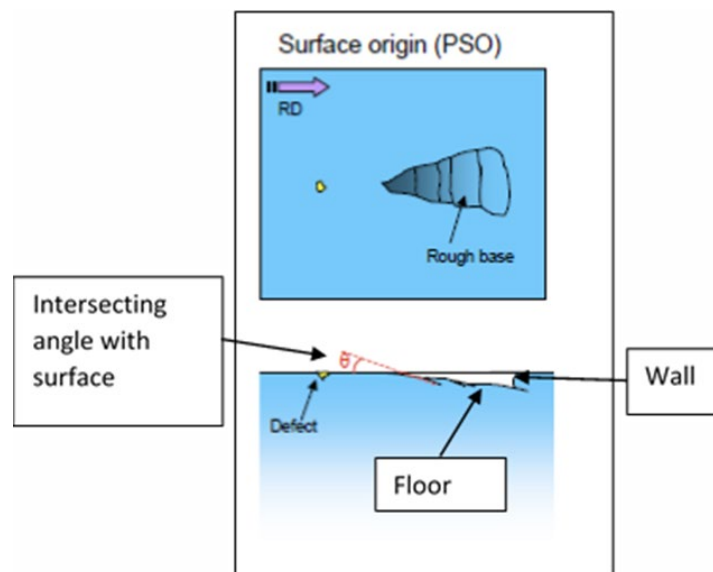


Figure 14

Illustration of typical surface RCF initiated from a surface defect

G-DVIO

On 3 January 2024, the AAIB received a notification from a British operator that they had rejected a tail rotor duplex bearing from an AW139 helicopter registered G-DVIO due to excess grease on the face of the bearing. The bearing was recovered by the AAIB and sent for disassembly and visual inspection by the same specialist lab. The bearing had 628 hours time since new.

Following disassembly, some minor wear was observed on the bearing cages, but there was no evidence of damage or RCF on the race surfaces. A cross section of the inner race was also examined for any subsurface microstructure changes, but no abnormalities were found.

AW169 bearing failure investigation

On 27 October 2018, G-VSKP an AW169 helicopter carrying a pilot and four passengers, lifted off from the centre spot of the pitch at the King Power Football Stadium in Leicester. The helicopter began to climb out of the stadium on a rearward flightpath while maintaining a northerly heading and with an average rate of climb of between 600 and 700 ft/min. The helicopter was briefly established in a right turn before an increasing right yaw rapidly developed, despite the immediate application of corrective control inputs from the pilot. The helicopter reached a radio altimeter height of approximately 430 ft before descending with a high rotation rate. The helicopter struck the ground on a stepped concrete surface, coming to rest on its left side. The impact damaged the lower fuselage and the helicopter's fuel tanks which resulted in a significant fuel leak. The fuel ignited shortly after the helicopter came to rest and an intense post-impact fire rapidly engulfed the fuselage. None of the occupants survived.

The investigation confirmed that the duplex bearing seized, causing the actuator control shaft to rotate, leading to the shaft unscrewing from the locking nut which kept it attached

to the flight control input lever. Once the nut was released, it allowed the control shaft to slide out of the pin carrier. This isolated the control shaft from both the pilot's control inputs and the control shaft's position feedback mechanism for the hydraulic system. That in turn allowed the hydraulic actuator to continue to drive the shaft, moving the tail rotor blades to their most extreme negative pitch position.

The investigation determined the following causal factors for this accident:

1. Seizure of the tail rotor duplex bearing initiated a sequence of failures in the tail rotor pitch control mechanism which culminated in the unrecoverable loss of control of the tail rotor blade pitch angle and the blades moving to their physical limit of travel.
2. The unopposed main rotor torque couple and negative tail rotor blade pitch angle resulted in an increasing rate of rotation of the helicopter in yaw, which induced pitch and roll deviations and made effective control of the helicopter's flightpath impossible.
3. The tail rotor duplex bearing likely experienced a combination of dynamic axial and bending moment loads which generated internal contact pressures sufficient to result in lubrication breakdown and the balls sliding across the race surface. This caused premature, surface initiated rolling contact fatigue damage to accumulate until the bearing seized.

The duplex bearing used in the AW169 and AW189 tail rotor at the time was identical to the current AW139 bearing except for the specification of the steel used in the inner and outer bearing races.⁸ As well as the accident bearing, three other bearings were removed from service which exhibited various levels of damage, similar to the accident bearing. A further bearing was subject to rig test to simulate the failure mechanism. This also resulted in similar damage to the bearings removed from service. The sequence of deterioration based on the findings from each of these bearings is shown in Table 1.

	Inner race	Balls	Cage	Outer race	Grease
1	Witness mark band from passage of balls.	The ceramic balls impart a loading and traction force on the inner ring.			The friction forces locally heat the bearing making the grease work harder, the grease is pushed out of the contact.
2	A dark etched region (DER) is formed under the raceway as the microstructure is changed.			Although loaded by the balls, the geometry of the contact reduces the local stress, no DER yet.	Grease, goes from brown to black, becomes thicker and sticky in consistency, with lumps. Some separation of the oil and thickener material.
3	Surface traction creates grain-flow and microcracks.	Increased friction at contact with inner ring, some sliding	Creation of witness marks within cage pockets.	Witness mark band from passage of balls. Ball sliding wear marks.	

Footnote

⁸ See report section 'Tail rotor duplex bearing development history'.

4	RCF macro-cracking and creation of ring debris. Heating of inner ring affecting bulk microstructure (Heat affected zone and softening). Damage progresses with time creating increasingly rough running surface for balls.	The balls display crazing from heat and traction forces, lots more sliding and stopping of individual balls.	Cage slows relatively to individual balls (caused by other balls sliding). Friction between spinning balls and cage pocket forces cage towards seal, resulting in cage deformation and wear.	DER formed below the race surface. Grain flow at surface leading to RCF micro-cracking and micro pitting. Surface becomes rougher and produces debris.	Grease continues to degrade. The friction present heats the grease fully degrading its properties, eventually turning it to dust.
5	Cage debris are free to move about the bearing, becoming adhered to the race rolling surface.		Cyclic loading of cage pockets by uneven ball procession drive fatigue cracks through narrow and wide ends of cage pockets		
6	A mix of cage, race and grease debris become over-rolled by the balls which are no longer constrained by the cage. A hybrid alloy material is deposited over the race surface.	With the cage broken the path the balls can take becomes more erratic and less confined. The balls run over the hybrid material rolling in more layers of debris.	Two pockets completely fail. Cage breaks into two sections, inertia throws them against the outer ring. Lots of cage debris is created adding to the mix of ring debris and remaining grease.	With the failure of the cage, the ball path is no longer stable and so can lead to plastic deformation of edge of raceway.	
7	Large subsurface cracks form within the weak hybrid layer of material, breaking out large chunks and re-depositing them.	Balls impart RCF loading conditions on the surface and subsurface of the hybrid material.	The cage continues to produce large amounts of debris. Hybrid debris flakes transfer to the cage pockets.	Hybrid debris flakes transfer to the outer race rolling surface and are over-rolled.	
8	A full race width piece of hybrid material fails through subsurface RCF. The chunk of material enters the pathway of the next ball.	The next ball cannot fit within the gap between the two raceways with the additional chunk of hybrid debris present. The ball stops relatively to the outer ring, applying torque to the normally stationary inner race.	The cage section with the jammed ball stops. The second cage section stops when it meets the first section. The bearing is seized	The locked bearing applies torque through the bearing housing, sliding the outer race within its housing.	
9	The torque on the inner race drives the rotation of the TRA control shaft.			The torque between the outer race and the housing is reduced by the rotation of the shaft.	

Table 1

Damage sequence identified on AW169/AW189 bearing failures

There was significant variation in the operating lives of the failed bearings examined in the investigation. The extent of damage observed was not consistent with a simple relationship of increasing flight hours, with the accident bearing showing the maximum level of distress, while having the lowest service life (330 hours).

Analysis of the evidence collected during the AW169 investigation suggested that only a limited subset of manoeuvres generated combined loads sufficient to cause contact pressures within the bearing, that over time resulted in grease deterioration and race damage. The inherent flexibility in helicopter manoeuvres and diversity of atmospheric conditions in which they operate, results in significant potential variability in the duration, magnitude and frequency of exposure to the potentially damaging contact pressures associated with this subset of manoeuvres. These differences in the timing and severity of exposure to high contact pressures for each individual helicopter affected, resulted in significant potential variation in the accrued bearing life at which accumulation of damage was initiated, the rate at which the damage progressed towards failure and the extent of the damage observable at the time when they were inspected, following removal from service due to a maintenance inspection or as the result of an incident or accident.

Soon after the accident the helicopter manufacturer introduced a number of emergency inspection measures on both the AW169 and AW189. These were introduced by Alert Service Bulletins (ASB) which were subsequently mandated by EASA in a combination of emergency and standard ADs.

The first of these was Emergency AD 2018-0241-E, issued on 7 November 2018 and referenced ASB 169-120 and 189-213, which were issued on 5 and 6 November 2018 respectively. It mandated a one-time visual inspection of the servo-actuator installation. The AD was then superseded by Emergency AD 2018-0250-E on 19 November 2018. In addition to the requirements of the first AD, a precautionary one-off inspection of the duplex bearing was added. This resulted in an initial number of bearings being rejected from helicopters in-service, some of which were sent to the AAIB for further investigation.

The helicopter manufacturer then published ASB 169-125 and ASB 189-214 on 21 November 2018. Consequently, EASA issued Emergency AD 2018-0252-E to mandate them. This introduced a one-time inspection and breakaway torque check of the duplex bearing and inspection and reinstallation of the servo-actuator castellated locking nut.

The manufacturer and airworthiness authority then determined that repetitive inspections of the duplex bearing were necessary for continued monitoring of the fleet. The helicopter manufacturer published ASB 169-126 and ASB 189-217 accordingly, and EASA issued Emergency AD 2018-0261-E in November 2018 to mandate these inspections. A steady number of bearings were removed from service and were sent to the bearing manufacturer. Some were selected for further investigation, using a standardised process agreed with the AAIB.

In the period following the introduction of these inspections, tail rotor system rig tests were being conducted by the helicopter manufacturer. The test results showed that as the duplex bearing degraded, its operating temperature increased consistently. A modification was therefore developed to install and repetitively inspect a thermal strip, as an additional warning indicator of the condition of the duplex bearing. This was introduced by the helicopter manufacturer in ASB 169-135 and ASB 189-224 and mandated by EASA through the issue of AD 2019-0023 on 1 February 2019.

Operator feedback from the repetitive tail rotor inspections allowed improved techniques to be developed and the helicopter manufacturer published ASB 169-148 and 189-237, to provide instructions for more in-depth inspections of the duplex bearing. EASA issued AD 2019-0121 on 3 June 2019⁹ to require accomplishment of these actions.

After AD 2019-0121(R1) was issued, the helicopter manufacturer introduced into service a modification to the Vibration Health Monitoring (VHM) system fitted to the AW169 and AW189. The modification relocated an existing accelerometer sensor on the tail to the servoactuator control lever, to allow monitoring of the vibration signature of the duplex bearing and provide an optional aid for the continued airworthiness of the fleet.

While the modification itself was not mandated, the reporting of data from helicopters with the modification installed, was mandated. This requirement was included in a new AD 2019-0193 issued 7 August 2019, which also included revisions to the other inspection requirements and superseded AD 2019-0121(R1).

In early 2020, the helicopter manufacturer issued modification Service Bulletins 169-153 and 189-249. These introduced a new standard of tail rotor actuator. The control shaft now has a left-hand thread on the castellated lock nut and an additional washer fitted to the actuator end of the shaft. EASA then issued Airworthiness Directive 2020-0048 on 6 March 2020, which superseded AD 2019-0193.

This AD mandated the fitment of the new standard control actuator, with one-way interchangeability¹⁰. Fitting of the modified actuator alleviated the requirement to conduct an inspection of the castellated lock nut every 10 flight hours. All the other mandatory inspections were retained in the new AD.

The final change by the manufacturer was to develop a new tail rotor duplex bearing introduced into service by mandatory Service Bulletins 169-162 and 189-254 on 4 August 2020. Replacement with the new bearing was required within 400 flight hours or four calendar months of the SB issue date. The new bearing replaced the ceramic balls with steel balls. The new bearing had an introductory life limit of 400 flight hours. The SB also required time expired bearings to be returned to the manufacturer for inspection following replacement.

None of these safety actions were applied to the AW139 fleet, as the helicopter manufacturer considered it was not affected by this issue.

A further eight Safety Recommendations were made in the final AAIB report. The full report for this investigation can be found on the AAIB website.¹¹

Footnote

⁹ This was reissued later in June 2019 as R1 to correct inconsistencies between the AD and the ASB.

¹⁰ The old part number actuator can be replaced by the new part number actuator, but not the other way around.

¹¹ [Aircraft Accident Report AAR 1/2023 - Leonardo AW169, G-VSKP - GOV.UK](#) [accessed 1 May 2026].

Failure of critical parts in-service

Currently there is no requirement in the airworthiness regulations requiring manufacturers to conduct a sample assessment of critical parts, such as the tail rotor duplex bearing, for condition after removal from service, either at the end of its service life or following premature removal for unserviceability. This type of inspection programme could have helped to validate the assumptions used for the bearing discard life and inspection period calculations, and avoid in-service tail rotor control issues occurring by providing evidence of premature degradation of the bearing.

The general issue of inspecting critical parts following rejection from service is an ongoing concern that has been identified in several previous accident investigations, including the investigation into a fatal accident in 2016 caused by a gearbox failure on an Airbus Helicopters Super Puma LN-OJF¹², where a similar finding and recommendation was made to introduce an effective inspection programme.

In response, the European Union airworthiness authority included a proposed amendment to CS 29.602 in NPA¹³ 2022-01, which introduced the concept of a Continued Integrity Verification Programme (CIVP). In February 2023 the proposed regulation amendments were withdrawn by EASA, following their review of comments received from the industry during the consultation process for the NPA. Although EASA have committed to continue to review potential regulation change, at the time of writing of this report no further proposals have been put forward and the concern remains unaddressed.

Two Safety Recommendations were subsequently made in the report into the AW169 accident¹¹, which was issued in September 2023, to address the safety concern that critical parts were not being inspected in-service or following premature removal from service, resulting in valuable evidence being lost. The text of these recommendations is shown below:

Safety Recommendation 2023-022

It is recommended that the European Union Aviation Safety Agency amend Certification Specification 29.602 to require manufacturers to implement a comprehensive post-removal from service assessment programme for critical parts. The findings from this should be used to ensure that reliability and life assumptions in the certification risk analysis for the critical part or the system in which it operates remain valid.

Safety Recommendation 2023-023

It is recommended that the European Union Aviation Safety Agency require manufacturers to retrospectively implement a comprehensive post-removal from service assessment programme for critical parts, approved to Certification

Footnote

¹² See AAIB report AAR 1/2023 for more information on this accident. [Aircraft Accident Report AAR 1/2023 - Leonardo AW169, G-VSKP - GOV.UK](#) [accessed 1 May 2026].

¹³ Notice of Proposed Amendment.

Specification 29.602 requirements, already in service. The findings from this should be used to ensure that the reliability and life assumptions in the certification risk analysis for the critical part or the system in which it operates remain valid.

In response to recommendation 2023-22, EASA have stated that they will review the requirement for a CIVP. The AAIB have recorded this response as 'partially adequate-open', until a definitive response to the recommendation is received from EASA, allowing a final determination to be made.

EASA has rejected recommendation 2023-023, stating that they considered the existing regulations to be adequate to address the safety concern. The AAIB have recorded this response as 'not adequate - closed'

Analysis

G-CIMU bearing failure

The failure sequence following seizure of a tail rotor duplex bearing was investigated and replicated by test during the accident investigation into G-VSKP, an AW169. A similar failure process occurred with the tail rotor duplex bearing found damaged during maintenance on G-CIMU, an AW139, which has an almost identical tail rotor system design to the AW169.

Seizure of the bearing results in rotation of the actuator shaft, which on the AW169, G-VSKP, accident resulted in the input lever locking nut unwinding due to the right-hand thread direction, and the lever subsequently becoming disconnected. Free rotation of the actuator shaft meant no further damage occurred to the bearing, allowing important evidence on the failure mechanism to be recovered. On the AW139 the same locking nut has a left-hand thread. This meant when the bearing seized on G-CIMU, the nut tightened, preventing the actuator shaft from rotating any further and transferring the drive torque back into the bearing, forcing it to rotate. This resulted in severe heating and deterioration of the bearing due to friction, causing significant damage to the bearing inner and outer races (more than experienced with bearings on the AW169) until they distorted and lost material sufficiently that they no longer provided any resistance to the axial movement of the actuator. This allowed the actuator shaft to extend into the cover cap and create the hole identified during the maintenance inspection and would have resulted in the effective loss of tail rotor blade pitch control in operation.

Evidence suggests the resistance to axial movement of the actuator started to reduce in the last 15 hours of operation as the bearing deformed, but it's likely the complete loss of resistance occurred in the final moments of the last flight operated by the helicopter, as the crew did not report any control issues. Had this occurred while the helicopter was still airborne, then there would have been a similar loss of tail rotor control to that experienced on an AW139 in flight in 2012. If this had been in the hover phase of flight, for example during a landing on an oil rig, the outcome may have been more hazardous than the 2012 serious incident which managed to land.

Due to the level of damage exhibited on the G-CIMU bearing it was not possible to recover any evidence to identify what led to the initial seizure of the bearing. This was also the case with the investigation of a tail rotor duplex bearing failure on the AW139 in flight loss of tail rotor control in 2012. The other bearings inspected by the investigation did not provide any significant supporting evidence either. Although the bearing removed from G-CKYP showed evidence of RCF, the most likely explanation for this was one-off debris ingress. If this was a systemic issue for the bearing design or manufacturing process, it's likely that there would have been significantly more failures identified since the common bearing design was introduced into service on the AW139, AW189 and AW169 fleets.

AW169 and AW189 bearing failures

Some evidence of sliding rather than rolling was found on the balls from the G-CIMU bearing. Despite this, the overall lack of detailed evidence from the in-service failures of the AW139 bearings meant the investigation was unable to determine whether the AW139 bearing failures resulted from the same failure mechanism as that identified on the AW169 and AW189 bearings following the G-VSKP accident. However, there was also no evidence found that a common failure mechanism could be discounted. Given the similar bearing architecture and the medium size of the AW139 helicopter between the smaller AW169 and the larger AW189, this remains a significant risk. The manufacturer elected not to apply the same mitigation actions to the AW139, as introduced post-accident to the tail rotor system of the AW169 and AW189 helicopters, such as temperature indicating strips, a specific HUMS sensor and a new non-hybrid bearing. For the first two, the manufacturer stated this was not possible because of differences in the dimensions of the tail rotor actuator on the AW139. However, the new non-hybrid bearing could have been retrofitted to the AW139.

Manufacturer and EASA response

The initial response to the G-CIMU bearing failure, introduced by emergency SB and AD was aimed solely at refitted bearings. This response assumed that the removal and refitting process was responsible for the failure of the bearing. The introduction of the requirement not to refit bearings was introduced as a precaution following the 2012 incident but was not based on any empirical evidence. The rig test requested by the investigation demonstrated that removal of the bearing, even under worst case conditions, did not result in any damage to the bearing races and therefore could not have caused either of the bearing failures experienced in 2012 or 2022.

Following this finding, the manufacturer then introduced a repetitive inspection process on non-refitted bearings, but this was specifically targeted at higher life bearings above 1,200 hours. EASA chose not to mandate this inspection requirement, despite having done so for the initial inspection requirements after the failure was identified and for all the additional bearing inspection requirements on the AW169 and AW189 following the accident to G-VSKP. The findings from the AW169 investigation demonstrated that the bearing failure mechanism was not caused by routine RCF due to normal accumulation of operating time and the bearing which caused the accident failed after just 330 hours of operation. While the failure mechanism on the AW139 wasn't proven to be the same as the AW169, it has also not been proven to be a high life failure mechanism, and the existing inspection requirement offers limited additional protection from a low life failure below 1,200 hours.

When considered collectively the mitigation actions put in place by the manufacturer and EASA to address duplex bearing failures on the AW139 are substantially less than those introduced in response to the AW169 accident. While the left-hand thread on the actuator locking nut provides an effective mitigation to the tail rotor blade runaway scenario seen during the AW169 accident, and loss of control of the tail rotor with sufficient forward speed allows a controllable safe landing to be conducted as demonstrated with the 2012 incident. There is still a high risk associated with a loss of tail rotor control in the hover. This is particularly a concern for AW139 operations carrying passengers to offshore oil rigs, where all offshore landings and takeoffs transition to or from the hover.

The manufacturer and EASA were questioned by the investigation whether they considered the existing mitigation actions were sufficient. They stated that no additional actions were considered necessary at this time.

Even if the current mitigation for failure of the duplex bearing is considered sufficient, it is clear from the two incidents and the number of bearings removed from service that there is a premature failure mechanism present on a critical part which the manufacturer does not currently fully understand. Bearings removed from service for failing repetitive inspections are disposed of by the operator as there is no requirement to investigate them further. Waiting for bearings to fail completely and cause a loss of tail rotor control before investigating them is unlikely to provide any useful information, given the level of damage which occurs before an identifiable flight control issue highlights a problem.

Prior to the AW169 accident, there was no requirement in place, either regulatory or from the manufacturer, to conduct a sample assessment of bearing condition after removal from service for any of the AW139, AW189 or AW169 fleets. This could have helped to provide evidence of potential premature degradation issues, prior to the point where the level of damage resulted in evidence of the initial cause being lost. This requirement has now been introduced on the AW169 and AW189 replacement non-hybrid bearing, at least until sufficient service experience has been gained with the bearing.

This issue of inspecting critical parts following rejection from service is an ongoing concern that has been identified in several previous accident investigations, including the investigation into a fatal accident in 2016 caused by a gearbox failure on an Airbus Helicopters Super Puma LN-OJF¹⁴, where a similar finding and recommendation was made.

Footnote

¹⁴ See AAIB report AAR 1/2023 for more information on this accident. [Aircraft Accident Report AAR 1/2023 - Leonardo AW169, G-VSKP - GOV.UK](#) [accessed 1 May 2026].

In response, EASA included a proposed amendment to CS 29.602 in NPA¹⁵ 2022-01, which introduced the concept of a CIVP. In February 2023 the proposed regulation amendments were withdrawn by EASA, following their review of comments received from the industry during the consultation process for the NPA. Although EASA have committed to continue to review potential regulation change, at the time of writing this report no further proposals have been put forward, and the concern remains unaddressed.

The introduction of a programme to sample and inspect tail rotor bearings at a range of accumulated operating hours, as well as those removed from service prematurely by operators, would potentially provide valuable evidence to assist the manufacturer in identifying the cause of premature tail rotor duplex bearing failures on the AW139.

Therefore, the following Safety Recommendation is made:

Safety Recommendation 2026-003

It is recommended that Leonardo Helicopters S.p.A. implement a comprehensive inspection and assessment programme for tail rotor duplex bearings fitted to the AW139, which samples serviceable bearings removed at a range of accumulated operating hours, as well as those removed as prematurely unserviceable by operators. The findings from this should be used to ensure that the current mitigation actions are adequate to address the airworthiness risk from a failure of the bearing leading to loss of tail rotor control.

Pedal position monitoring

The flight crew did not report controllability issues after the last flight before the bearing damage was discovered. The CVR did capture a comment by one of the pilots relating to the pedal positions being abnormal. The review of pedal position during cruise indicates that the relationship between the pedal position and the actuator position required to achieve the required tail rotor thrust was approximately stable until about 15 flight hours before the failure was found. It then progressively shifted.

Monitoring of trends in the average pedal position during cruise portions of flights provides a means of identifying a similar degradation of the tail rotor duplex bearing. Therefore, the following safety recommendation is made:

Safety Recommendation 2026-004

It is recommended that Leonardo Helicopters S.p.A. explore monitoring for pedal position trends under stable flight conditions to provide early indication of deterioration of the tail rotor duplex bearing, on all helicopter types fitted with such a bearing, as part of its Health and Usage Monitoring System programme.

Footnote

¹⁵ Notice of Proposed Amendment.

Vibration monitoring of the tail rotor duplex bearing

The tail rotor duplex bearing is a critical part. As a result of the catastrophic failure of the AW169 tail rotor duplex bearing on G-VSKP, the manufacturer added a capability to monitor vibration of the bearing on the AW169 and AW189 fleet. It is understood from the manufacturer that the same implementation modification is not viable for the AW139 fleet due to differences in the tail rotor actuator design. However, other means may be possible. Therefore, the following recommendation is made:

Safety Recommendation 2026-005

It is recommended that Leonardo Helicopters S.p.A establish and introduce vibration monitoring of the AW139 tail rotor duplex bearing as part of its Health and Usage Monitoring System capability to provide early indication of deterioration of the bearing.

Conclusion

The failure of an AW139 tail rotor duplex bearing was identified during a post flight maintenance check from wear damage on the bearing/actuator cover. The extent of the damage to the bearing confirmed that a loss of tail rotor control event would likely have occurred had the helicopter continued to operate with the bearing in its degraded condition. Despite a full forensic assessment, the bearing was too badly damaged to determine the initial cause of failure.

It was identified that the bearing had been refitted to the helicopter, after removal for maintenance, in contravention of the AMM. The initial response by the helicopter manufacturer and regulator was to require removal of all AW139 duplex bearings which had been refitted, along with reducing the discard life of the bearing to align with the maintenance task interval. A SB and AD were issued to mandate this. The assumption by the manufacturer was that the removal process for the bearing caused damage that initiated the deterioration of the bearing. However, this was subsequently discounted by the results of a rig test. The manufacturer then issued a further SB reducing the inspection interval for high life bearings over 1,200 hours. No AD was issued to mandate this requirement.

The tail rotor duplex bearing is defined as a critical part and the failure of an almost identical design of bearing fitted to an AW169 helicopter, resulted in a fatal accident in 2018. None of the safety actions introduced on the AW169 and AW189 global fleets in response to this accident, were applied to the AW139 global fleet. The same failure mechanism could not be excluded by the investigation and no evidence was identified to suggest the failure was due to routinely accrued high service life on the bearing.

Three Safety Recommendations have been made relating to the introduction of an inspection programme to help identify the cause of the AW139 tail rotor duplex bearing failures and to introduce potential means of early identification of degradation of the bearing using data trends recorded by the HUMS system.

Safety actions/Recommendations

Safety Recommendation 2026-003

It is recommended that Leonardo Helicopters S.p.A. implement a comprehensive inspection and assessment programme for tail rotor duplex bearings fitted to the AW139, which samples serviceable bearings removed at a range of accumulated operating hours, as well as those removed as prematurely unserviceable by operators. The findings from this should be used to ensure that the current mitigation actions are adequate to address the airworthiness risk from a failure of the bearing leading to loss of tail rotor control.

Safety Recommendation 2026-004

It is recommended that Leonardo Helicopters S.p.A. explore monitoring for pedal position trends under stable flight conditions to provide early indication of deterioration of the tail rotor duplex bearing, on all helicopter types fitted with such a bearing, as part of its Health and Usage Monitoring System programme.

Safety Recommendation 2026-005

It is recommended that Leonardo Helicopters S.p.A. establish and introduce vibration monitoring of the AW139 tail rotor duplex bearing as part of its Health and Usage Monitoring System capability to provide early indication of deterioration of the bearing.

Safety Actions

The helicopter manufacturer issued Technical Information Letter T-139-22-004 in June 2022 reminding operators that the tail rotor duplex bearings fitted to AW139 should not be refitted after removal, in accordance with the AMP.

A Temporary Maintenance Instruction 139-559 was issued in June 2022 by the helicopter manufacturer to modify the maintenance procedure to state clearly that a removed bearing must be discarded.

Emergency Alert SB 139-725 was issued in July 2022 by the manufacturer, along with Technical Information Letter T139-22-006 to provide directions on removal from service of bearings which had been refitted and or exceeded 2,400 FH.

EASA issued the Emergency Airworthiness Directive (EAD) No. 2022-0182-E, which mandated SB 139-725. The discard time of the bearing was also reduced from 3,000 FH to 2,400 FH in the AMPI Chapter 5.

Comments of the ANSV representing the state of design

Chapter 6.3 of Annex 13 to the Convention on International Civil Aviation provides that the State conducting the investigation shall send a copy of the draft Final Report to all States that participated in the investigation, inviting their significant and substantiated comments on

the report as soon as possible. If the State conducting the investigation receives comments within the period stated in the transmittal letter, it shall either amend the draft Final Report to include the substance of the comments received or, if desired by the State that provided comments, append the comments to the Final Report. Those comments are included below.



30th April 2026

Air Accident Investigation Branch
Farnborough House, Berkshire,
Copse Road, Aldershot, Hampshire,
United Kingdom, GU11 2HH

Subject: comments on the draft final report about the AW139 registration marks G-CIMU incident.

Dear Sir,

thank you for having invited the ANSV to participate as Accredited Representatives in the investigation to the incident which occurred to AW139 registration marks G-CIMU, Norwich Airport, 13 June 2022, and for the opportunity to provide comment on the final report.

The ANSV together with its Technical Advisers, Leonardo Helicopters and the European Union Aviation Safety Agency, have extensively reviewed the final report.

A large number of detailed comments have been provided to the UKAAIB during the consultation phase. In order to make as simple as possible to understand the key areas of disagreement from the ANSV perspective, they are summarized as follows.

1. Occurrence classification

The UKAAIB draft final report begins in the Synopsis paragraph: *«The failure of an AW139 tail rotor duplex bearing was identified during a post flight maintenance check from wear damage on the bearing/actuator cover. The extent of the damage to the bearing confirmed that a loss of tail rotor control event would likely have occurred had the helicopter continued to operate with the bearing fitted.»*.

From the ICAO Annex 13, an incident is: *«an occurrence, other than an accident, associated with the operation of an aircraft which affects or could affect the safety of operation.»*

On the other hand a serious incident is: *«an incident involving circumstances indicating that there was a high probability of an accident and associated with the operation of an aircraft which, in the case of a manned aircraft, takes place between the time any person boards the aircraft with the intention of flight until such time as all such persons have disembarked, or in the case of an unmanned aircraft, takes place between the time the aircraft is ready to move with the purpose of flight until such time as it comes to rest at the end of the flight and the primary propulsion system is shut down. Note 1. The difference between an accident and a serious incident lies only in the result.»*

Considering the circumstances, the description of the event seems to fit with the classification of incident. Indeed, the original classification attributed by the UKAAIB was *incident*.

Now, withstanding the autonomy of a Safety Investigation Authority to open an investigation also on incidents and recognizing the quality of the investigation report, together with the interesting insights the report brings, it is important to highlight that the difference view on the classification remains something more meaningful than simply taxonomical: indeed, the classification provides the reader with an immediate information on the level of risk of an event, in this case without an actual flight and presented as potentially involving multiple fleets. Indeed, the report makes continuous and direct reference to the AW169 and its duplex bearing; while it is true there are commonalities in the two helicopters, in the respective tail structures and relevant duplex bearings, the AW139 and AW169, together with AW189, are different helicopters with duplex bearings that have different part



numbers. On the AW139 specifically, the fleet accumulated millions of flight hours¹ with no accidents for matters possibly related to the duplex bearing; over the years LH has managed all the notifications from the operators regarding potentially degraded bearings, performing the investigations on all bearings returned from service. In this framework, despite the monitoring system already in place and despite the request made by LH, only a limited number of bearings was returned to LH for investigation, showing no deterioration instead.

The duplex bearing from the one only in-flight case, from 2012, had a life significantly longer than the maximum allowed nowadays. In addition, that event ended without consequences for the helicopter and for the occupants. This would further demonstrate a failed duplex bearing does not imply necessarily an accident as consequence. Indeed, the event from 2012 was classified as incident. In fact, this supports the idea that the occurrence should be classified as incident and the report should be more addressed on the AW139 duplex bearing, better considering the robustness demonstrated in the reality of the operations.

2. Normal airworthiness process

The final report proposes three safety recommendations. Besides any possible consideration on the efforts needed for the implementation, that may make it not commensurate with the expected benefits, the positive intent for increasing safety is understood. However, the report seems to not give enough credit to the already efficient inspection and assessment activities set in the normal airworthiness process². This is particularly meaningful considering also the introduction of SB 139-728, which requires operators to send to LH for further investigation any bearing found potentially degraded and removed from service.

All the above also considering that: *«Both the investigation and an audit by the UK regulator of the operator's maintenance procedures, identified that the maintenance process used to refit all the tail rotor duplex bearings at the operator's facility didn't comply with the AMM procedure.»*

Indeed, the occurrence should highlight mainly the uppermost importance of respecting maintenance provisions, in the airworthiness process, namely in this case the forbidden re-usage of bearings and the procedure that require operators to send to manufacturer for inspection and further investigation of any suspect duplex bearings found in service.

The ANSV applies the right to append this letter of comments to the final report, as permitted by ICAO Annex 13 section 6.3.

¹ 4.690.742 FH (flight hours) at the date of 31 October 2025.

² Point 21.A.3A of Annex I (Part 21) to Regulation (EU) No 748/2012 defines the obligations applicable to the Type Certificate Holders (TCHs) to establish and maintain a system for collecting, investigating and analyzing occurrence reports. This includes, as per point 21.A.3A(a)(1), identification of adverse trends or deficiencies that might cause adverse effects on the continuing airworthiness of the product. In addition, acceptable means of compliance AMC1 21.A.3A(a) clarifies that, for parts whose failure could lead to an unsafe condition (and critical parts are candidates as they could have catastrophic effect upon the rotorcraft), the analysis function of the system should ensure that reports and information sent, or available, to the Design Approval Holder (DAH) are fully investigated so that the exact nature of any event and its effect on continuing airworthiness is understood. This may then result in changes to the design and/or to the Instructions for Continued Airworthiness (ICA), and/or in establishing a mitigation plan to prevent or minimize the possibility of such occurrences in the future, as necessary.

To comply with 21.A.3A, Leonardo Helicopters (LH) applies the relevant procedures accepted by EASA within the Approval Certificate EASA.21J.005 of the LH DOA dated 26/01/2004:

- occurrence reporting and management;

- guidance criteria for the classification of occurrence report, including the annex A, "Guidelines for adverse trend management applicable to critical parts".

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