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AAIB
Air Accidents Investigation Branch

AAIB Bulletin S2/2018
SPECIAL

ACCIDENT

Aircraft Type and Registration:	Agusta AW169, G-VSKP
No & Type of Engines:	2 Pratt & Whitney Canada PW210A turboshaft engines
Year of Manufacture:	2016 (Serial no: 69018)
Location	King Power Stadium, Leicester
Date & Time (UTC):	27 October 2018 at 1937 hrs
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 4
Injuries:	Crew - 1 (Fatal) Passengers - 4 (Fatal)
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Airline Transport Pilot's Licence (A and H)
Commander's Age:	53 years
Commander's Flying Experience:	To be confirmed Last 90 days - 40 hours Last 28 days - 7 hours
Information Source:	AAIB Field Investigation

The investigation

The accident occurred at 1937[1] hours on 27 October 2018. The AAIB published Special Bulletin S1/2018 on 14 November 2018 to provide preliminary information gathered from the site investigation, subsequent technical investigation, recorded data, and other sources.

Footnote

[1] All times in this bulletin are UTC and have been taken from a variety of sources which have yet to be fully correlated. All times quoted should be taken as approximate at this stage.

This second Special Bulletin provides information on the findings to date of a detailed examination of the helicopter's yaw control system.

Description of the AW169 yaw control system

Yaw pedals in the cockpit are connected to the tail rotor control system by a flexible cable running on ball bearings within an outer casing. This is connected to one end of a rigid control rod via a bellcrank. The range of movement of the bellcrank is limited in each direction, providing the primary control stops for the yaw system (Figure 1).

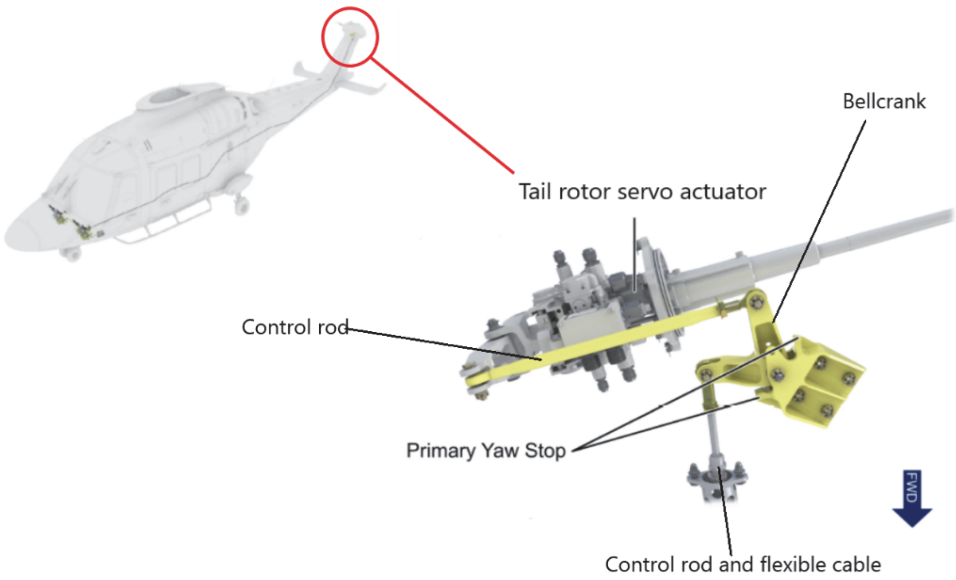

Figure 1

AW169 tail rotor control yaw stops

The other end of the control rod is connected to one end of a lever mechanism which forms part of the tail rotor servo actuator. The lever mechanism transmits the pilot's yaw commands to the servo actuator and, through a feedback mechanism, stops movement of the actuator when the commanded position has been reached.

The middle of the lever is connected via a solenoid valve to the hydraulic servo shuttle valve, and the other end of the lever is connected to the hydraulic servo control shaft by a connecting pin and pin carrier.

The pin carrier is secured to the shaft by a castellated locking nut, which attaches to a threaded section on the end of the shaft. The nut has a torque load applied before a split pin is fitted between the castellations of the nut and through a hole in the shaft. It is also wire locked in place (Figure 2).

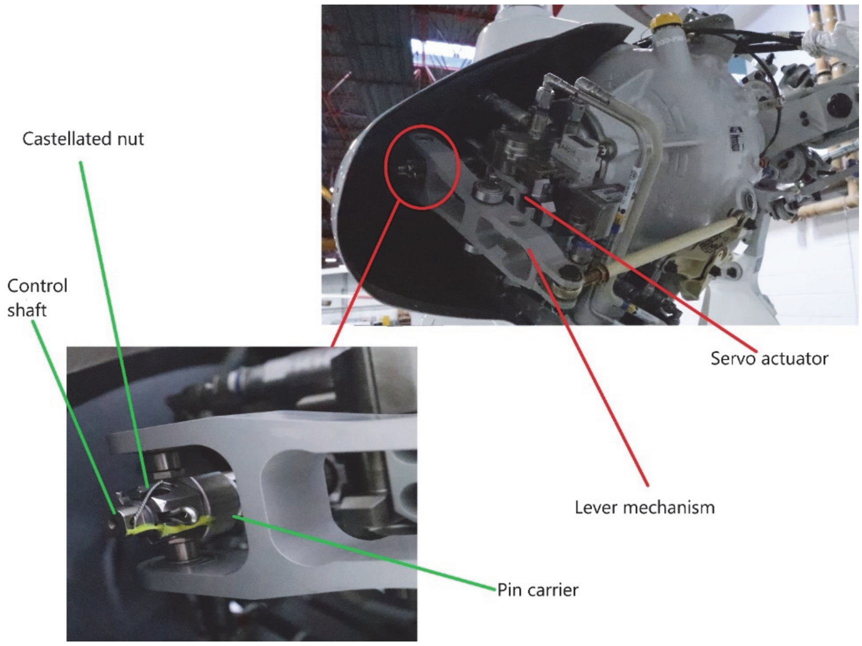

Figure 2

Tail rotor actuator control input mechanism

The control shaft passes through an outer shaft, which forms part of the tail rotor hydraulic actuator piston, and continues through a tunnel in the gearbox and engages with the inner race of a duplex bearing installed in the tail rotor slider/spider assembly (Figure 3). The control shaft is secured to the inner race of the bearing with a second, larger, castellated nut and split pin.

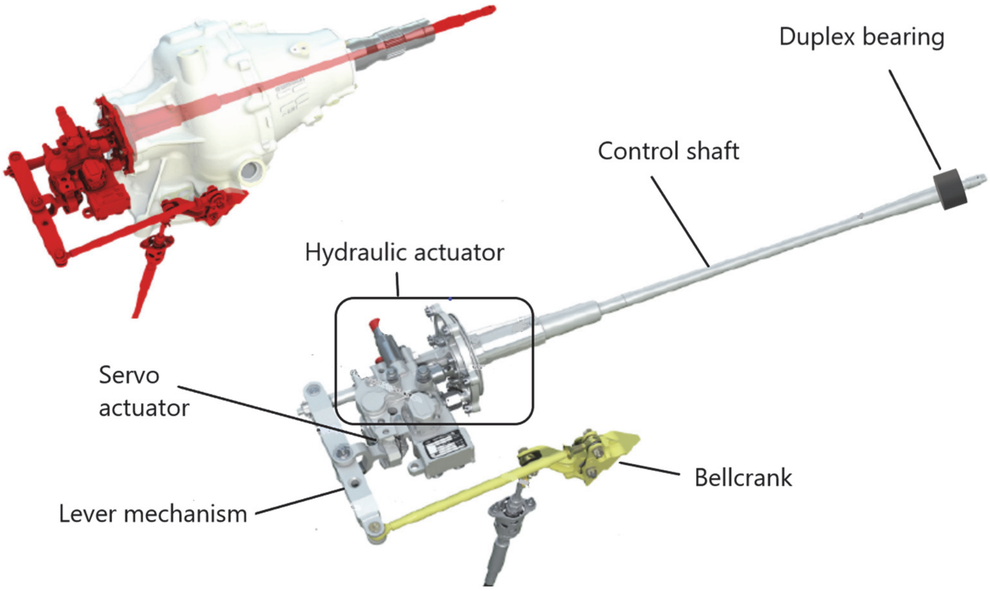

Figure 3

AW169 tail rotor actuator and duplex bearing

Each arm of the spider is connected by a rod to the rear of a tail rotor blade. The spider/slider assembly rotates with the outer race of the duplex bearing, while the control shaft attached to the inner race remains stationary (Figure 4).

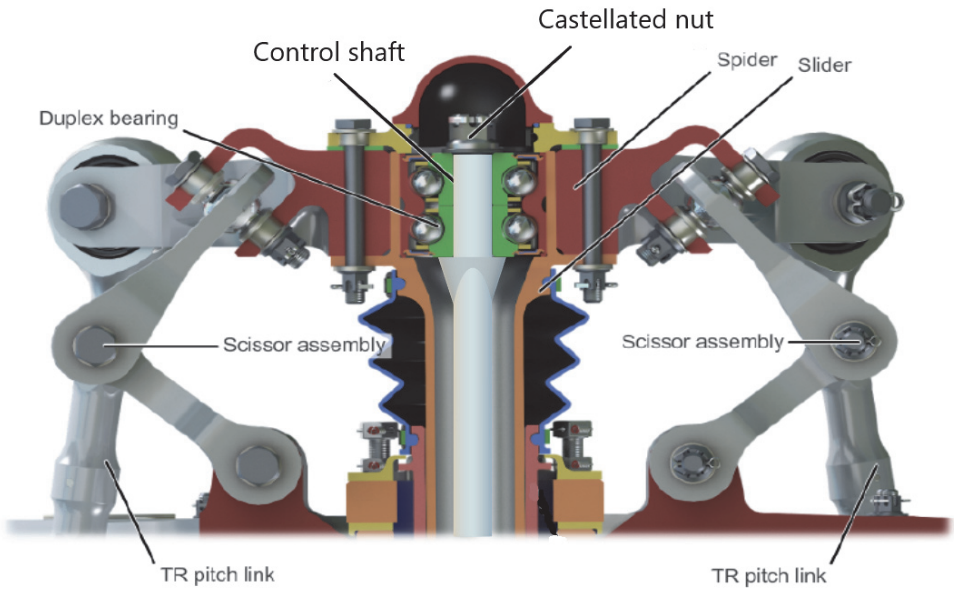

Figure 4
Tail rotor spider and pitch link assembly

Tail rotor control operation

When the pilot applies a yaw pedal input it moves the control cable and rotates the bellcrank. This movement is transferred to the lever mechanism by the control rod. The lever pivots around the connection at the control shaft end and creates a demand on the hydraulic system via the solenoid valve, which moves the hydraulic piston and control shaft of the actuator. Movement of the shaft is transmitted to the tail rotor blades via the spider/slider assembly and the blade control rods, which change the tail rotor pitch to meet the pilot's command. As the shaft moves it moves the lever mechanism, closing the solenoid valve and stopping movement of the actuator when the tail rotor blade pitch matches the control input.

Findings from the technical investigation

The tail rotor control system was first inspected at the crash site. This identified that the input lever mechanism was not attached to the control shaft. The pin, spacers and one of the locating bearings were missing from the lever. The locking nut and pin carrier were found loose in the tail rotor fairing and were bonded together (they should be separate components). The threads of the nut appeared to be undamaged. There was no evidence of the split pin, and the control shaft threaded section had moved inside the outer shaft and was no longer visible.

The control shaft, the locking nut and pin carrier, and the duplex bearing/sliding unit assembly were removed from the wreckage and inspected in detail. The locking nut on the bearing end of the control shaft was found to have a torque load significantly higher than the required assembly value. The inner races of the bearing could only be rotated a few degrees in either direction by hand. There was a build-up of black grease inside the slider unit around the inboard face of the duplex bearing. The section of the control shaft adjacent to this bearing face showed evidence of burnt-on grease and was discoloured along its length (Figure 5).

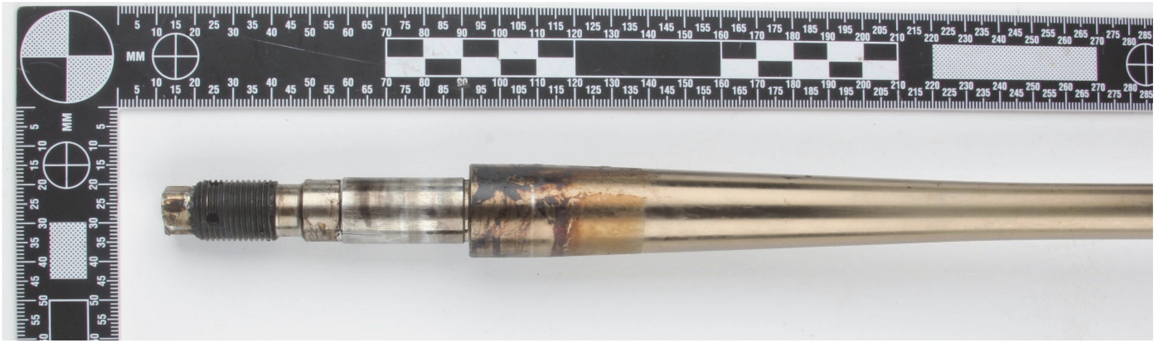

Figure 5

Duplex bearing location on tail rotor actuator control shaft after removal

The components were then inspected using a Computed Tomography (CT) Scanner. This uses x-rays to image the inside of the components, then recreates them as a 3-D model. The results showed that the nut and pin carrier were friction welded together. The threaded portion of the control shaft, at the actuator end, was inside the outer shaft and contained the remains of the split pin. The top and bottom of the split pin had been sheared off in rotation (Figure 6).

The scan of the bearing showed fractures to the bearing cages and significant damage to the surface of the inner bearing races, the damage being worse on the inboard bearing race (Figure 7) where there was also evidence of sub-surface damage.

The scan also showed evidence of debris accumulating in the bearing raceways (Figure 8).

The bearing was then removed from the sliding unit and disassembled, revealing evidence of relative rotation between the sliding unit and the bearing outer ring. The debris present on the CT scan was identified as a combination of black dust and metallic particles. No grease, in its original form, remained in the bearing. Visual inspection of the surface of the bearing races confirmed the extent of the damage seen in the CT scans.

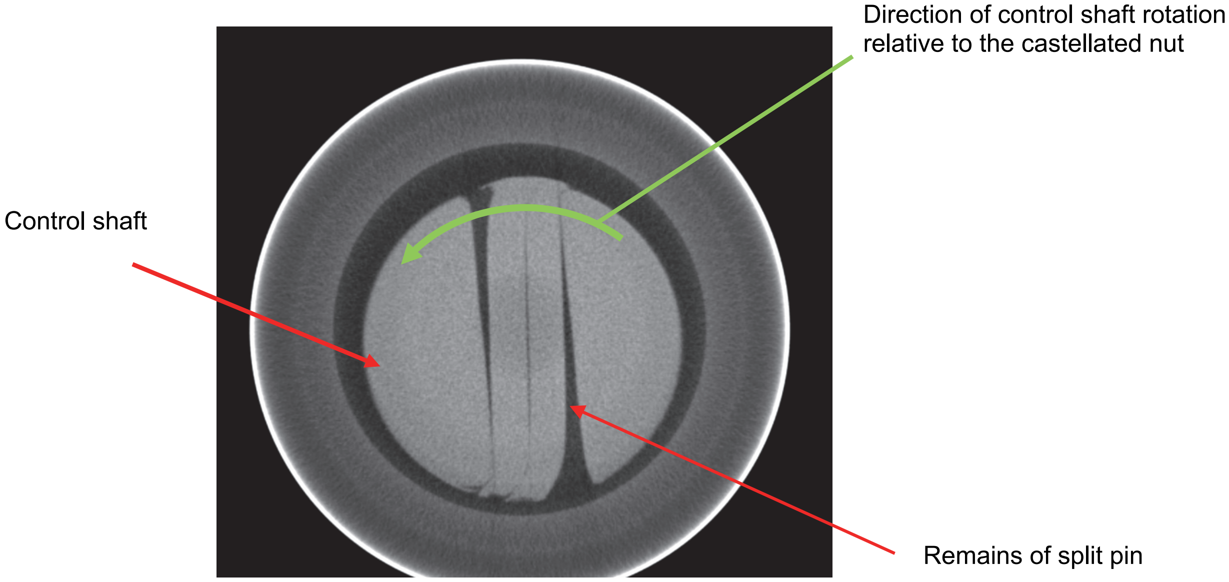

Figure 6

CT Scan through tail rotor actuator control shaft (viewed from actuator end)

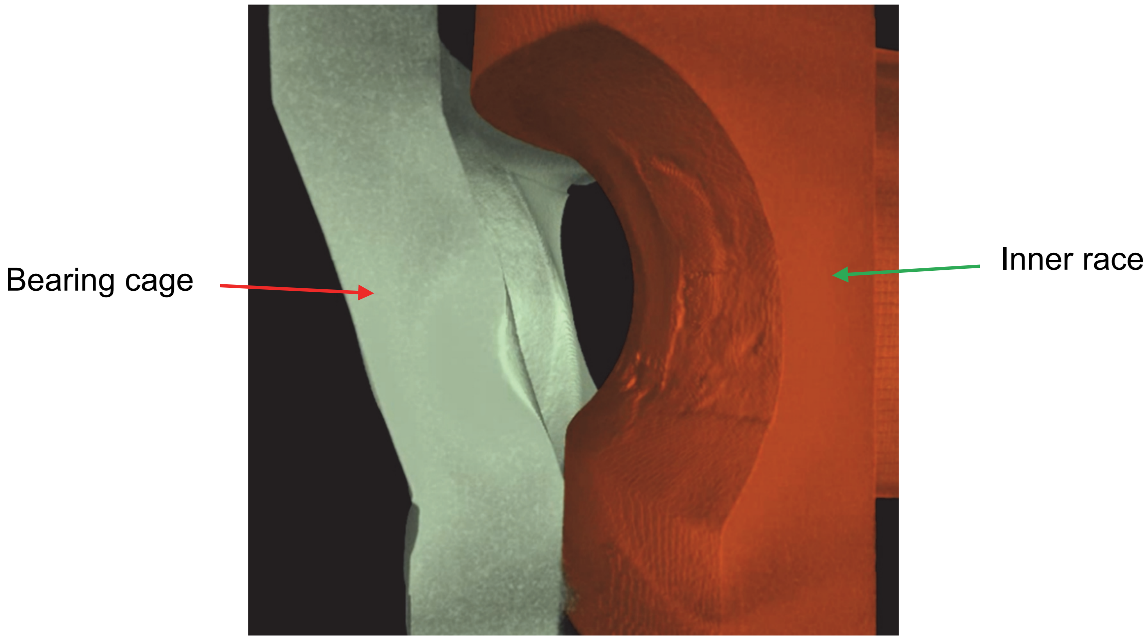

Figure 7

CT imagery of duplex bearing inboard inner ring surface damage

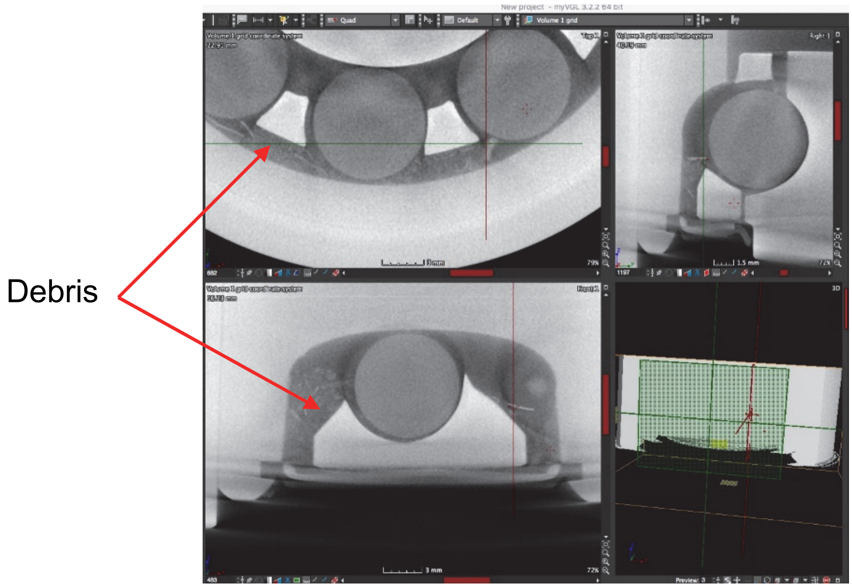

Figure 8

Scan images of duplex bearing showing raceway debris accumulation

Failure sequence

The evidence gathered to date shows that the loss of control of the helicopter resulted from the tail rotor actuator control shaft becoming disconnected from the actuator lever mechanism. Disconnection of the control shaft from the lever prevented the feedback mechanism for the tail rotor actuator from operating and the tail rotor actuator from responding to yaw control inputs. Loss of the feedback mechanism rendered the yaw stops ineffective, allowing the tail rotor actuator to continue changing the pitch of the tail rotor blades until they reached the physical limit of their travel. This resulted in an uncontrollable right yaw.

Sufficient force and torque had been applied to the castellated nut on the actuator end of the control shaft to friction weld it to the pin carrier and to shear the installed split pin. The observed condition of the duplex bearing and the increased torque load on the castellated nut that remained on the spider end of the shaft is consistent with rotation of the tail rotor actuator control shaft. Whilst the shaft was rotating and a yaw control input was applied, the shaft “unscrewed” from the nut, disconnecting the shaft from the actuator lever mechanism, and causing the nut to become welded to the pin carrier.

Safety actions

On 5 November 2018 the manufacturer of the helicopter issued Alert Service Bulletin (ASB) 169-120 for AW169 helicopters, giving instructions for a precautionary inspection of the tail rotor control assembly on all helicopters in the global fleet. On 6 November the manufacturer also issued ASB 189-213 for AW189 helicopters, which have a similar tail rotor control system.

The European Aviation Safety Agency (EASA), in its capacity as the regulator responsible for the type design approval of the AW169 and AW189, issued Airworthiness Directive 2018-0241-E dated 7 November 2018 to mandate these inspections.

On 19 November 2018 the EASA issued AD 2018-0250-E, superseding AD 2018-0241-E, to require a precautionary one-time inspection of the tail rotor duplex bearing and, depending on findings, applicable corrective actions.

On 21 November 2018 the helicopter manufacturer published Emergency Alert Service Bulletin ASB169-125 for AW169 helicopters, and ASB189-214 for AW189 helicopters, giving further instructions for a one-time inspection of the tail rotor duplex bearing. The EASA issued AD 2018-0252-E on 21 November 2018, superseding AD 2018-0250-E and mandating this inspection.

On 30 November 2018 the helicopter manufacturer published Emergency Alert Service Bulletin ASB 169-126 for AW169 helicopters, and ASB 189-217 for AW189 helicopters, introducing repetitive inspections of the castellated nut that secures the tail rotor actuator control shaft to the actuator lever mechanism, and the tail rotor duplex bearing. The EASA issued AD 2018-0261-E on 30 November 2018 mandating the repetitive inspections.

Ongoing investigation

The initiating cause and exact sequence of the failure that resulted in the loss of tail rotor control is being investigated as a priority. Work continues to identify the cause of the damage observed to the duplex bearing and to establish its contribution to the failure sequence. The AAIB is working with relevant organisations to identify any other factors that may have contributed to the loss of tail rotor control.

The other areas of investigation specified in Special Bulletin S1/2018 will continue, and the AAIB will report any significant developments as the investigation progresses.

Published 6 December 2018.