ACCIDENT

Aircraft Type and Registration:	Westland Wasp HAS1, G-KAXT
No & Type of Engines:	1 Rolls-Royce Nimbus MK 10301 turboshaft engine
Year of Manufacture:	1967 (Serial no: F9669)
Date & Time (UTC):	23 September 2016 at 0845 hrs
Location:	Bishopstone, Salisbury, Wiltshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Broken universal joint and collective pitch control rod, damaged tail rotor and driveshaft, structural damage
Commander's Licence:	Private Pilot's Licence
Commander's Age:	63 years
Commander's Flying Experience:	984 hours (of which 379 were on type) Last 90 days - 21 hours Last 28 days - 8 hours
Information Source:	AAIB Field Investigation

Synopsis

With the helicopter straight and level at approximately 1,150 ft, the pilot felt vibration through the collective lever. The vibration ceased after two or three seconds.

Approaching higher ground, the pilot pulled up on the collective lever but the helicopter did not respond. He lowered the lever and again, there was no response. Faced with a loss of collective pitch control, the pilot made a precautionary landing, but was unable to control the flare. The tail rotor struck the ground but the helicopter remained upright. The pilot and his passenger were uninjured.

The investigation established that the collective pitch control rod in the main rotor gearbox had broken. The control rod failure was secondary to a universal joint failure that had occurred in the cyclic control circuit due to lack of lubrication and a build-up of corrosion deposits. The pilot had reported vibration in the preceding months but despite diagnostic efforts, the cause had not been identified.

The Civil Aviation Authority (CAA) issued Emergency Mandatory Permit Directive No 2017-002-E, applicable to UK-registered Westland Wasp and Scout helicopters, to perform a visual check of the condition of the universal joint and introduce periodic

lubrication of the joint. One Safety Recommendation has been made to the CAA to review the maintenance requirements for ex-military aircraft.

History of the flight

The pilot and his passenger departed Barton Ashes in Hampshire with the intention of flying to Royal Naval Air Station (RNAS) Yeovilton, where they were scheduled to participate in a fly-in of historic naval helicopters.

Southwest of Salisbury, at approximately 1,150 ft and 80 kt, the pilot felt a two to three second vibration in the collective lever. Shortly thereafter, the pilot realised that he no longer had collective pitch control, so he turned away from rising ground in preparation for a diversion to a landing site in the Chalke Valley.

The pilot made a PAN call and informed Air Traffic Control (ATC) of his intention to land as soon as possible. He was offered diversionary airfields, but with increasing concern over the ability to control his altitude he decided to land in a field near the village of Bishopstone. After a slow speed handling check, he initiated his final approach and selected manual throttle control at a height of approximately 300 ft. His ability to flare was limited and he was unable to cushion the landing, with one wheel touching down first and significant bouncing between all four wheels as he shut the helicopter down. The tail rotor struck the ground but the helicopter remained upright and both occupants, who were uninjured, were able to exit normally.

Helicopter description

General

The Westland Wasp HAS1 was designed to fulfil the Royal Navy's requirement for a shipborne anti-submarine helicopter. It was part of the same programme as the British Army Westland Scout and was introduced in 1964. It was retired by the Royal Navy in 1988.

The helicopter has a four-wheeled castering landing gear and is powered by a Rolls-Royce Nimbus engine, which drives a four-bladed main rotor and a two-bladed tail rotor. The tail boom and main rotor blades can be folded to allow storage in small hangars onboard ship.

Flying controls

The pilot flying controls comprise a collective pitch lever to the left of the pilot's seat, a cyclic control column in front of the seat and a pair of tail rotor control pedals to provide directional control.

The control rods from the collective pitch and cyclic control column run aft under the cabin floor and, through a series of bell cranks and levers, extend upwards to the control spider at the base of the main rotor shaft (Figure 1).

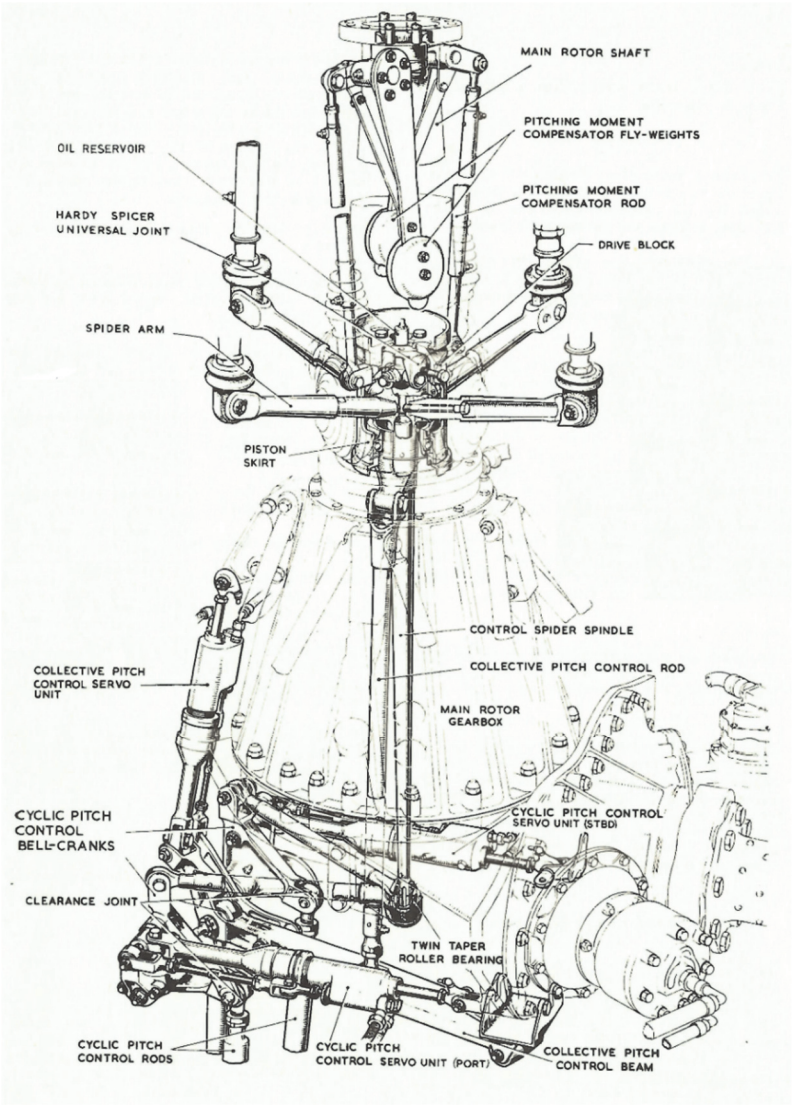

Figure 1

Main rotor gearbox controls

Operation of the collective pitch lever raises or lowers the control spider to alter the pitch of all four main rotor blades by equal amounts. This increases or decreases rotor lift and controls the vertical movement of the helicopter.

Movement of the cyclic control column in any direction is transmitted to the spider which tilts to correspond to the angle of the column. When the rotor is running the tilted spider produces a cyclic change of blade pitch, which tilts the main rotor disc and introduces a horizontal component to the rotor reaction.

The pitching moment compensator provides a balanced collective control in flight by relieving collective pitch control loads imposed by the main rotor blade pitching moments. This comprises of a pair of flyweights, pivoted in bearing blocks at the top of the main rotor shaft and connected by rods to the control spider piston.

G-KAXT

G-KAXT was delivered into service with the Royal Navy in February 1967 with the UK military registration XT787. The helicopter was transferred to the Royal New Zealand Air Force (RNZAF) in 1982, where it remained in service until May 1998. It was subsequently returned to the manufacturer with approximately 2,660 flying hours before being acquired by a private owner and recommissioned in 2000.

When the accident occurred, G-KAXT had accrued 3,012 flying hours and was operating on the UK civil register with a valid Permit to Fly.

The pilot, who also owned the helicopter, advised that vibration had been identified in the months preceding the accident but investigation had been unable to identify the cause. An experienced Scout pilot had expressed concern over the severity of the vibration, but the helicopter had successfully completed an air test four days prior to the accident.

Helicopter examination

Examination, under the supervision of the AAIB, identified that the collective pitch control rod in the main rotor gearbox had broken. The failure occurred in an area where the rod passes through an aperture in a metallic 'guide' (Figure 2). By design, the rod should not touch the guide.

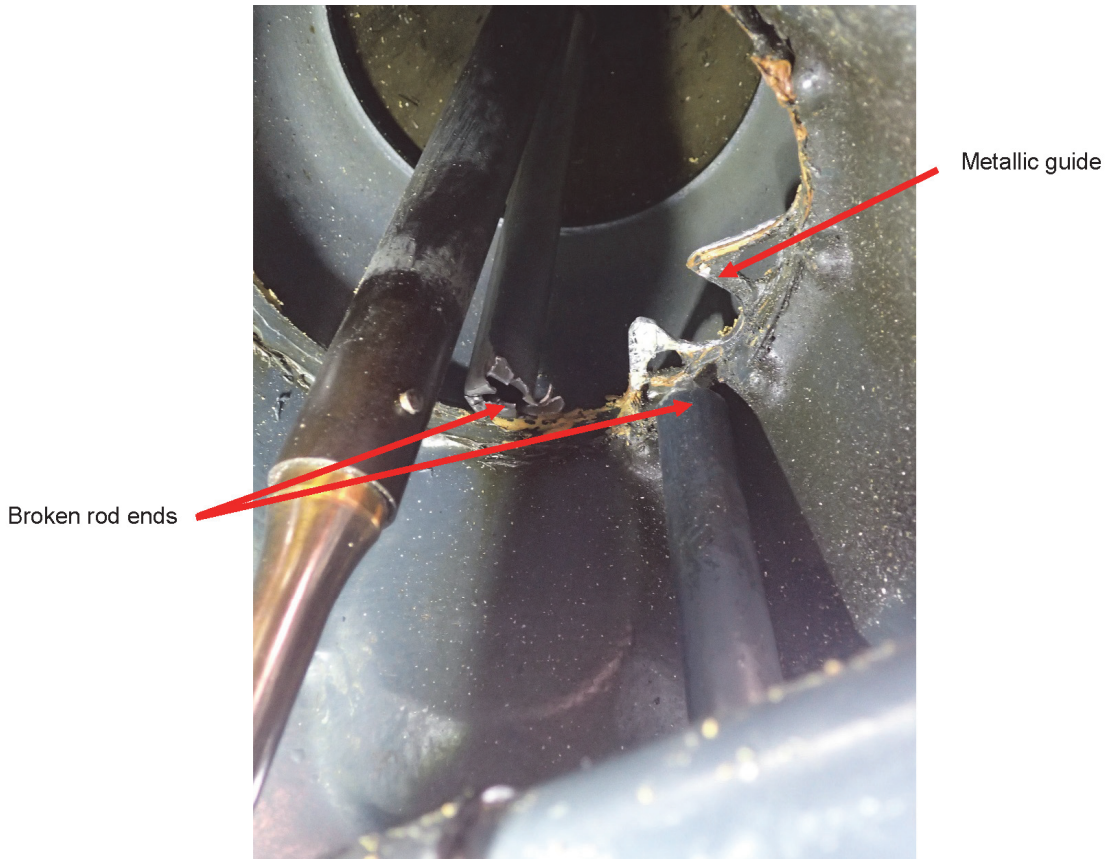

Figure 2
Broken collective pitch control rod

Collective pitch control rod

The circumferential fracture faces had been damaged by repeatedly impacting the surrounding structure and it was not possible to establish the initiating failure mechanism. Nevertheless, axial cracks extended approximately 30 mm away from the failure and the metallurgist identified features that were indicative of fatigue.

Spider (control hub) assembly

The main rotor gearbox was removed and disassembled to access the control hub assembly and the upper section of the broken collective pitch control rod (Figure 3). All four spider arms showed evidence of unexpected wear due to repeated contact with the vertical slots in the main rotor drive shaft, which exhibited corresponding wear.

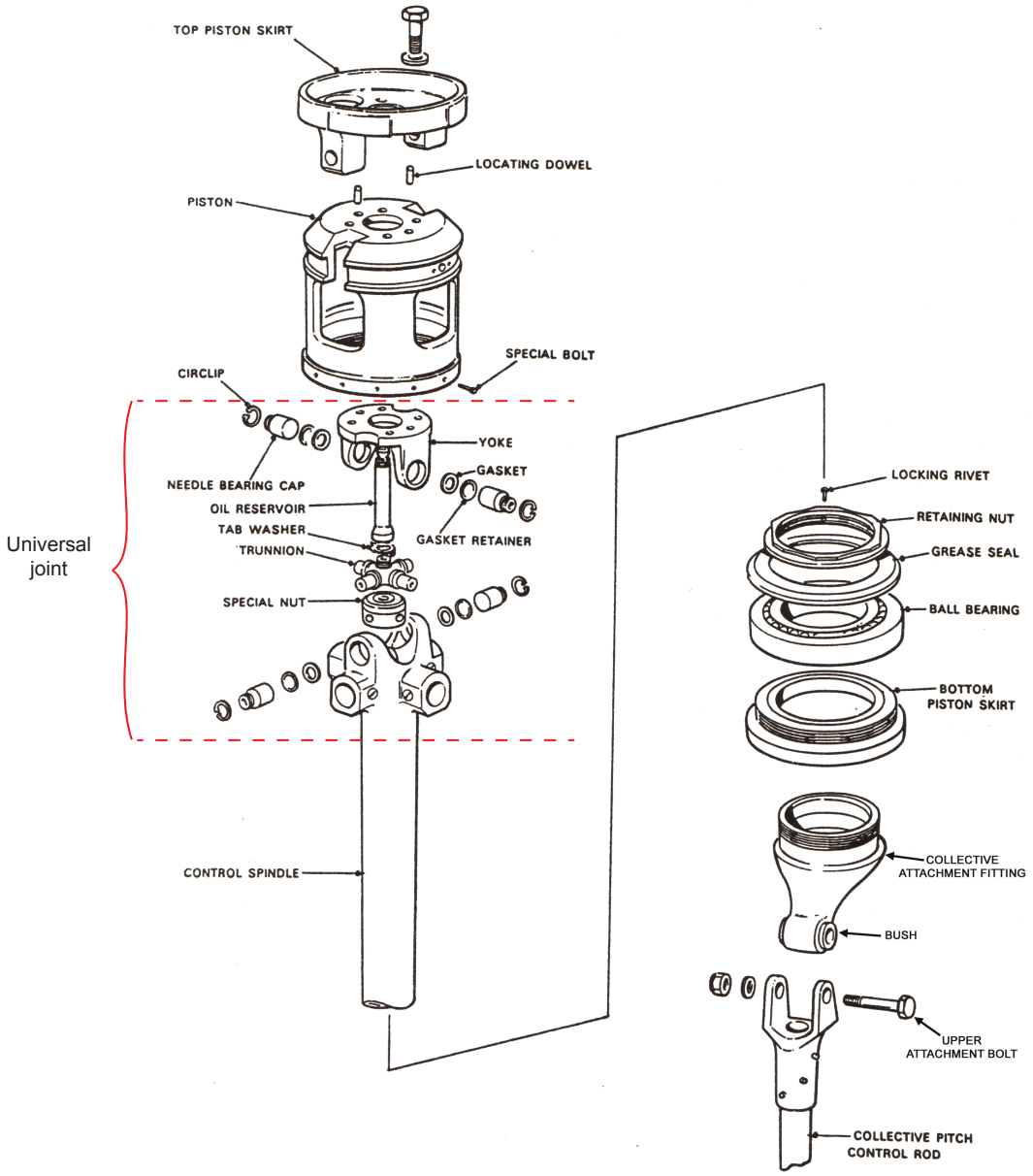

Figure 3

Control hub assembly

The joint between the collective pitch control rod and the collective attachment fitting exhibited excessive play. The bolt and bushes (both of which were cracked) were found to be outside the allowable wear limits. The excess play would allow lateral movement of the control rod resulting in contact with the metal guide.

Further examination of the control hub assembly identified corrosion on the universal joint and one of the 'ears' of the cyclic control spindle had broken, allowing the universal joint trunnion to become partially free. A cylindrical component found loose within the gearbox was identified to be the oil reservoir and an indentation on it had been made by contact with the adjacent piston skirt.

Control spindle and universal joint

Corrosion deposits on the fracture faces of the broken control spindle ear indicated that the failure was not recent (Figure 4). Localised bluing of the material was indicative of an overheat condition. Both bearing caps were corroded and sections of their outer walls were missing; only four needles from the two needle bearing assemblies were identified.

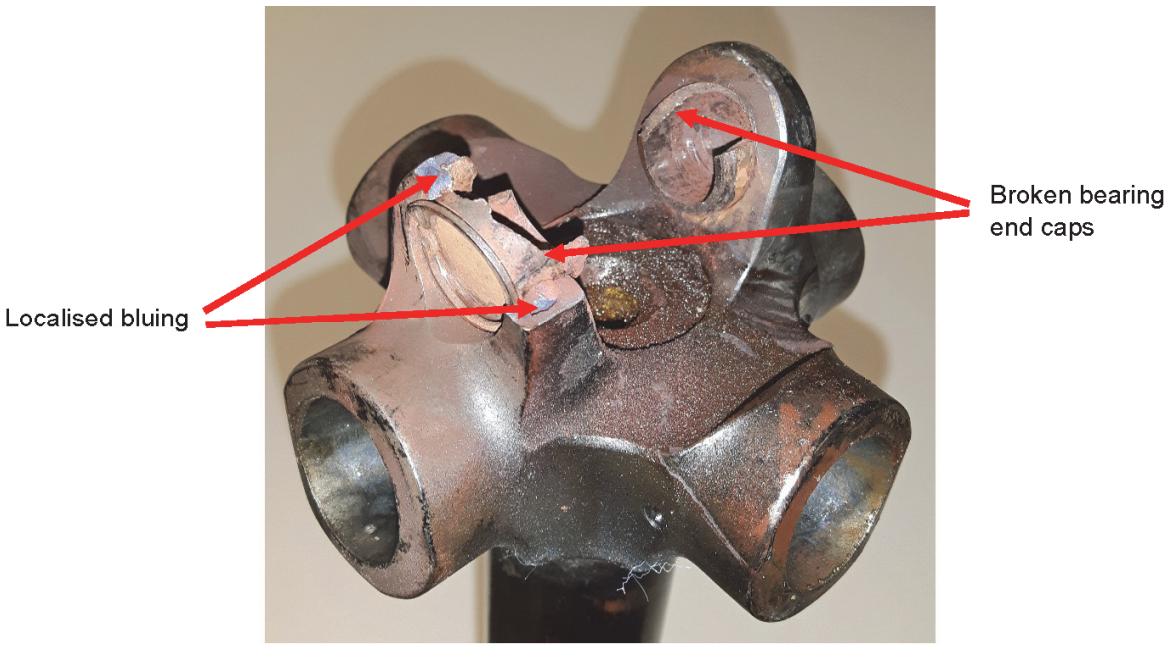

Figure 4

Control spindle showing corrosion, broken ear and damaged end caps

The exposed bearing surfaces of the trunnion showed extensive corrosion and wear (Figure 5). Attempts to move the trunnion about the axis that remained intact required undue force and the range of movement was restricted to approximately 10°. The evidence indicated that that the universal joint had been operating with insufficient lubrication for a considerable period of time.

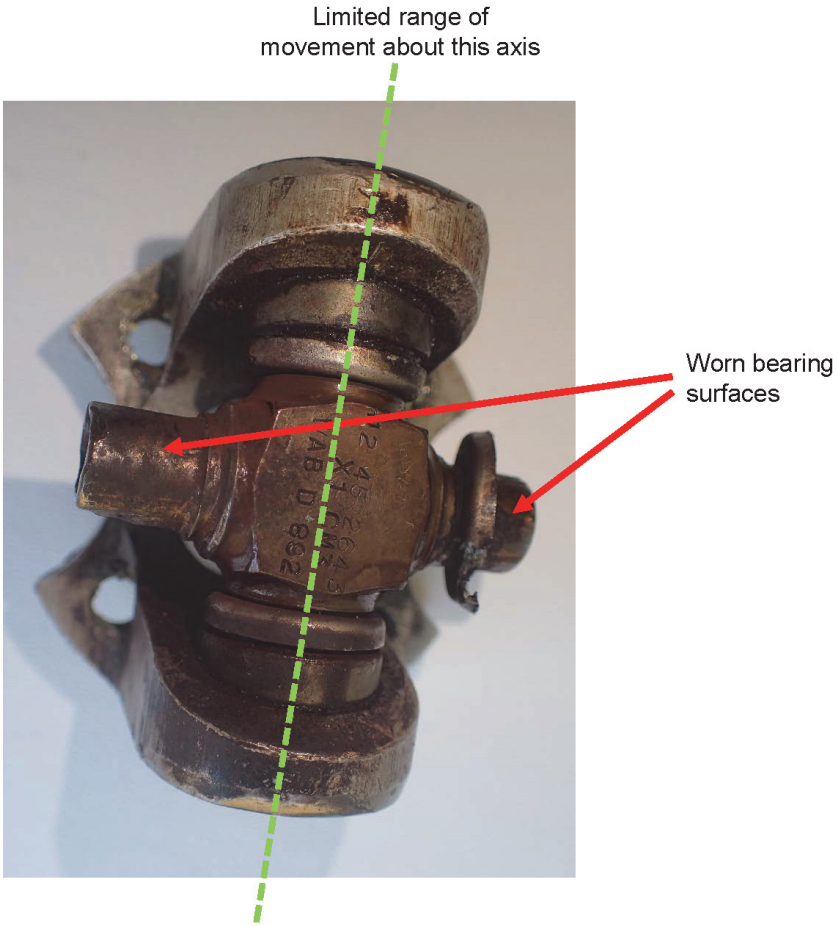

Figure 5

Corroded universal joint trunnion and worn bearing surfaces

Maintenance procedures

General

The helicopter was maintained in accordance with the Ministry of Defence (MoD) Master Maintenance Schedule (MMS), reference AP101C-0601-5A1; this was a condition of the CAA approval for the Permit to Fly.

Main rotor gearbox

The scrap life of the main rotor gearbox is 2,400 hours and the overhaul periodicity depends on the equipment modification state. In the case of G-KAXT, the overhaul period was 600 hours.

The manufacturer advised that typical usage for the Wasp helicopter in UK military service was in the order of 200 hours per year, which would equate to a gearbox overhaul calendar period of approximately three years.

Universal joint

According to AP101C-0601-5A1, a new universal joint must be installed every 600 hours.

The helicopter maintenance manual (AP101C-0601-1A) states that the oil reservoir is lubricated on assembly using OEP 740 oil. The control hub assembly procedure in the gearbox overhaul manual (AP101C-0700-6B) states '*fully charge the reservoir with oil OEP 740*'.

There are no requirements to lubricate the universal joint in service.

Main rotor gearbox history

The main rotor gearbox was installed on G-KAXT in August 1996. The gearbox had accrued 1,777 hours prior to installation and had just been overhauled by the RNZAF. The universal joint was replaced during gearbox overhaul but the provenance of the replacement item is unknown, with the log card stating: '*universal replaced (temp number issued – no serial number supplied with item)*'.

At the time of this accident the gearbox had been installed on G-KAXT for 429 hours, which had been accrued over a period of 20 years.

Analysis

Loss of collective pitch control

When the collective pitch control rod failed, the pilot lost the ability to control the pitch angle of the main rotor blades using the collective lever. The manufacturer considered that catastrophic loss of pitch control was prevented by the pitching moment compensator, which provides a balanced collective control by relieving loads imposed by rotor blade pitching moments. The pilot retained a degree of collective control by varying rotor speed but his ability to control the flare was limited.

Failure mechanism

The mechanical damage indicated that the universal joint had been operating without lubrication for an extended period of time. The manufacturer considered that vibration would have been expected and the pilot advised that vibration had been identified in the months preceding the accident. The cause had not been established and an experienced Scout pilot who had flown in G-KAXT had expressed concern over the severity of the vibration. Irrespective of this, however, the helicopter had successfully completed an air test four days prior to the accident.

The vibration caused accelerated wear and cracking in both bushes in the pitch rod upper attachment fitting. The excess wear allowed lateral movement of the control rod and, therefore, contact with the metal guide. Repeated contact with the guide eventually resulted in the rod failing due to fatigue.

Maintenance aspects

G-KAXT was maintained in accordance with the original military schedule. This required the main rotor gearbox to be overhauled every 600 hours and the universal joint to be replaced at the same interval. The universal joint must be lubricated on installation. Maintenance records showed that the main rotor gearbox on G-KAXT was overhauled in 1996 and a replacement universal joint was installed at this time. The manufacturer advised that typical usage for the Wasp helicopter in UK military service was in the order of 200 hours per year, which would equate to a gearbox overhaul calendar period of about three years. However, due to the low utilisation in civilian operation, in the 20 years since the main rotor gearbox was overhauled, G-KAXT had accrued only 429 hours. Whilst the gearbox was within the required overhaul period of 600 hours, the elapsed calendar time was far greater than would have been expected in military service. The extended elapsed calendar time resulted in the universal joint oil reservoir being depleted, resulting in inadequate lubrication of the joint and its eventual failure.

Safety action

The investigation findings were highlighted to the CAA at an early stage. The CAA took urgent action to ensure the continued airworthiness of Westland Wasp and Scout helicopters on the UK register by issuing Emergency Mandatory Permit Directive (EMPD) No 2017-002-E. *(http://publicapps.caa.co.uk/modalapplication.aspx?appid=11&mode=detail&id=7759)*

The EMPD requires operators to perform a visual check of the condition of the universal joint and conduct periodic lubrication of the joint.

The investigation established that the original military maintenance schedule did not always define calendar-based criteria for maintenance operations, some of which may be critical to ensuring continued safe civil operation. The military servicing regimes were derived for aircraft in military service with a relatively high utilisation. However, civilian-operated ex-military aircraft typically have a much lower utilisation and the original military maintenance schedule may no longer be entirely appropriate. The following Safety Recommendation is therefore made:

Safety Recommendation 2017-012

It is recommended that, for ex-military aircraft on the UK civil register, the Civil Aviation Authority requires maintenance and overhaul tasks to be reviewed in the light of the expected aircraft utilisation and calendar-based time limits introduced where appropriate. Where such calendar-based time limits already exist, these should be reviewed to ensure that they are appropriate for the aircraft utilisation.

Conclusion

The investigation established that the collective pitch control rod in the main rotor gearbox had failed, resulting in the loss of the ability to control the blade pitch via the collective lever. The control rod failure was secondary to a universal joint failure in the cyclic control circuit due to lack of lubrication in the joint and a build-up of corrosion deposits.

The much lower utilisation in civilian operation, and the absence of a calendar time limit for main rotor gearbox overhaul, meant that the gearbox in G-KAXT had been installed for 20 years since previous overhaul. The universal joint had not been replaced in this time and there was no requirement to lubricate it in service. The lubricant in the joint was lost over time, causing the joint to wear and corrode, leading to its eventual failure. The introduction of calendar-based time limits, where appropriate for the aircraft utilisation, would help to prevent similar failures in the future.