ACCIDENT

Aircraft Type and Registration:	Enstrom 280FX Shark, G-OJMF
No & Type of Engines:	1 Lycoming HIO-360-F1AD piston engine
Year of Manufacture:	1999 (Serial no: 2086)
Date & Time (UTC):	8 February 2012 at 1425 hrs
Location:	Manchester Barton Airport
Type of Flight:	Training
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Tail rotor; rear fuselage and left landing gear skid
Commander's Licence:	Private Pilot's Licence
Commander's Age:	38 years
Commander's Flying Experience:	3,905 hours (of which 3,890 were on type) Last 90 days - 33 hours Last 28 days - 23 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and AAIB examination of tail rotor bearing

Summary

The pilot experienced a lack of tail rotor authority and elected to do a run-on landing at Manchester Barton. The helicopter veered after landing and the tail rotor struck the ground. The lack of tail rotor control was due to the separation of the flange on the tail rotor pitch change bearing.

History of the flight

The pilot was conducting a navigation exercise when, at the first turning point, he experienced a "feeling of lack of full tail rotor authority". More specifically, there was no response to left pedal inputs. He conducted a gentle turn to the right and elected to return to the airfield, which was approximately 20 nm distant, and transmitted a PAN call on arrival. He decided to conduct a run-on landing on grass Runway 14. Although the initial touchdown was straight, the helicopter veered to the right and encountered rough, frozen ground at the side of the runway. This caused the helicopter to bounce on its skids such that the tail rotor struck the ground prior to coming to a halt. As a result the tail rotor assembly, together with the rear of the tail boom, were damaged (see Figure 1). The pilot was uninjured.

The investigation

Before the aircraft was moved, it was noted that the yaw control cable on the left side of the tail boom had been

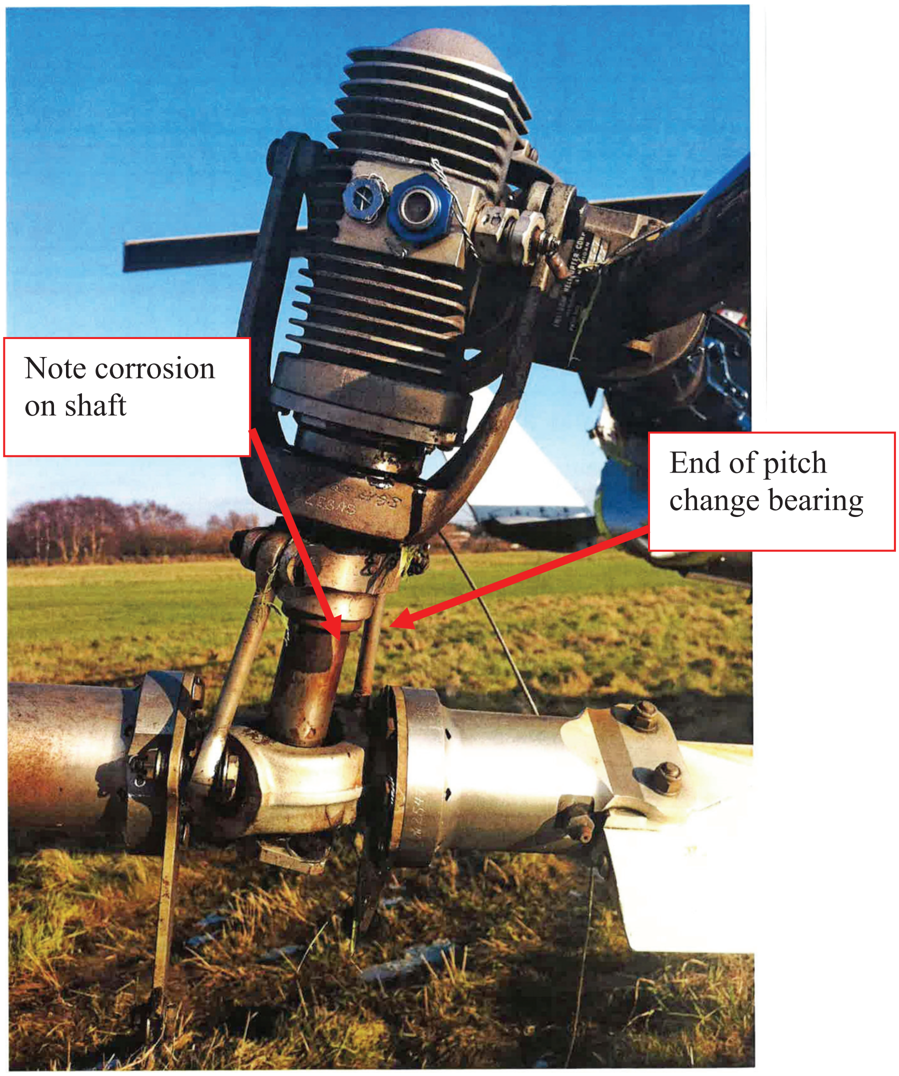

Figure 1

Tail rotor assembly after the accident

severed. The helicopter manufacturer commented that they were aware of rare occurrences of cables being severed in flight, but only during violent manoeuvres. In this case it was concluded that the cable was cut as a result of the damage sustained during the landing.

After disassembly of the tail rotor it was observed that that the flange on the inboard end of the bronze pitch change bearing had broken off and was missing. Figure 2 shows the salient details of the tail rotor drive and pitch control components.

The pitch change bearing is keyed to the tail rotor shaft. It is also pinned to the pitch link retainer such that both components rotate with the tail rotor shaft whilst contained within the bearing housing assembly. The pitch link retainer is connected to the yaw controls and moves axially along the shaft in response to yaw pedal movements.

It was immediately apparent that the flange on the inboard end of the pitch change bearing had broken away and was missing. The separated portion would have to have broken into several pieces in order *not*

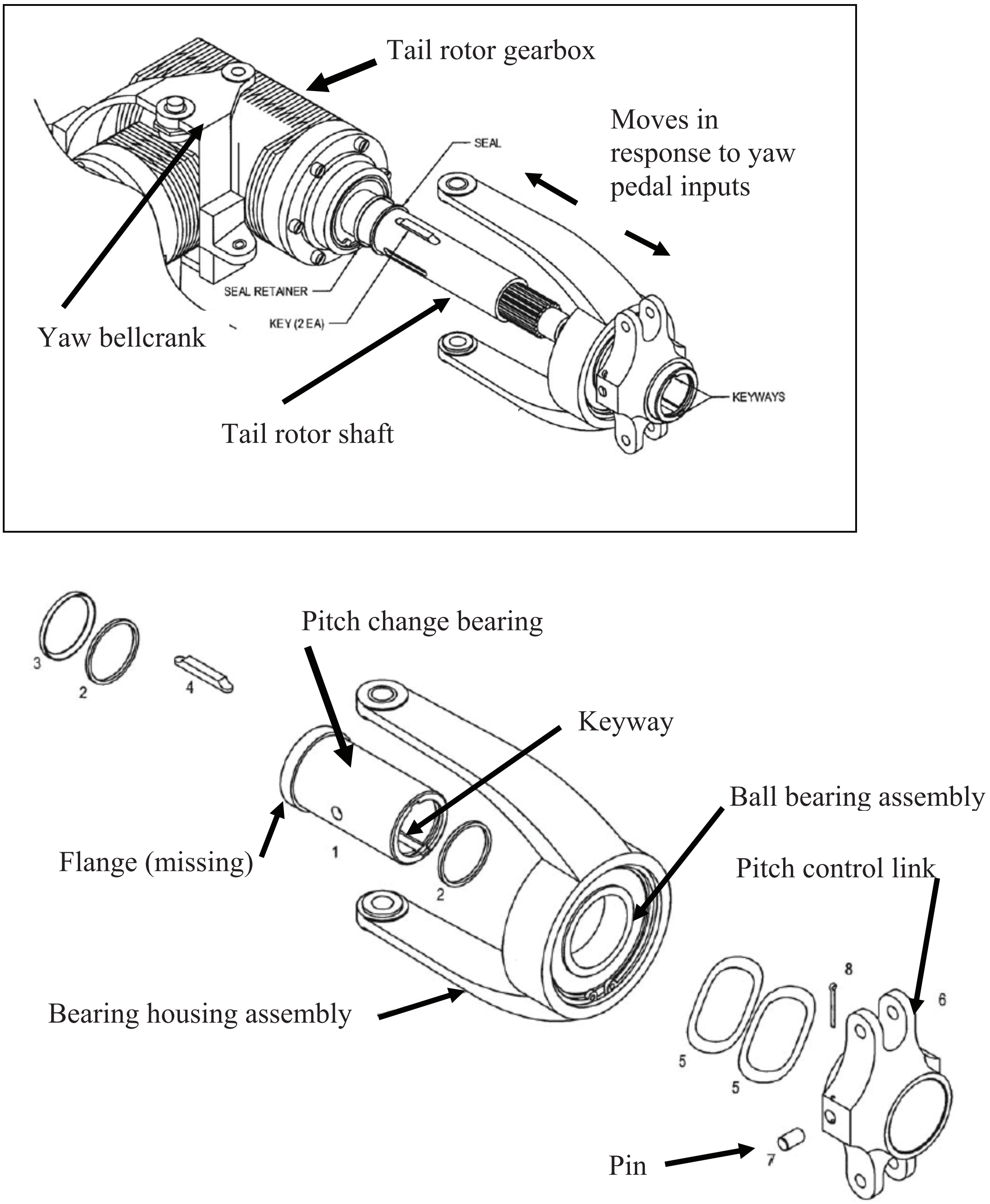

Figure 2

Tail rotor pitch control details (adapted from illustrated parts catalogue)

to have been retained on the shaft. The helicopter manufacturer stated that they were unaware of any previous bearing failures of this nature.

The remaining part of the bearing was sent to the AAIB where it was subjected to a metallurgical examination.

Bearing investigation

The bearing, which was manufactured from sintered bronze, was examined under a microscope and the fracture face was found to be covered with grease-like deposits, with the staining more prominent over

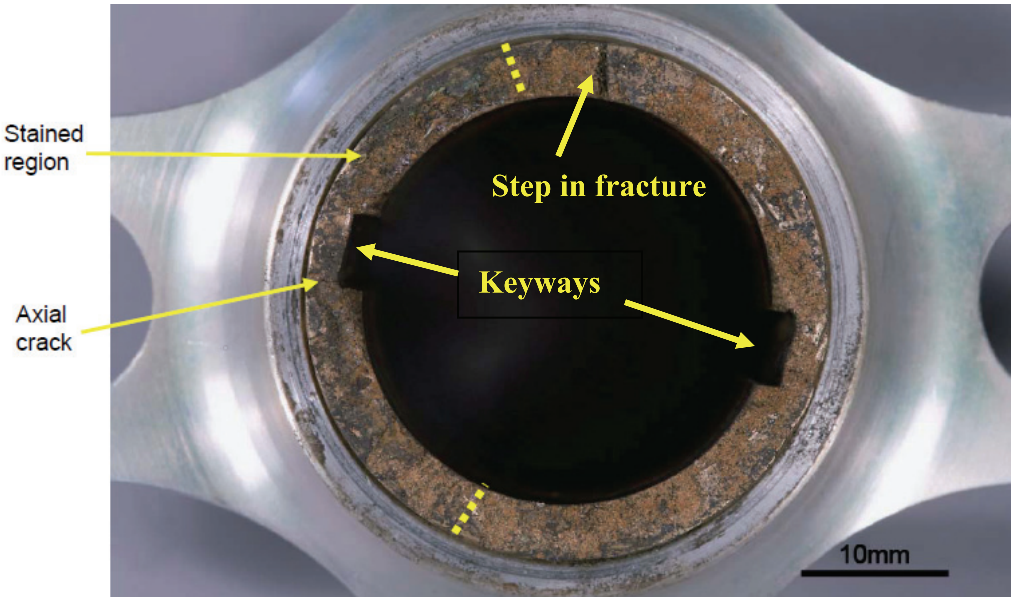

Figure 3

View of bearing fracture face

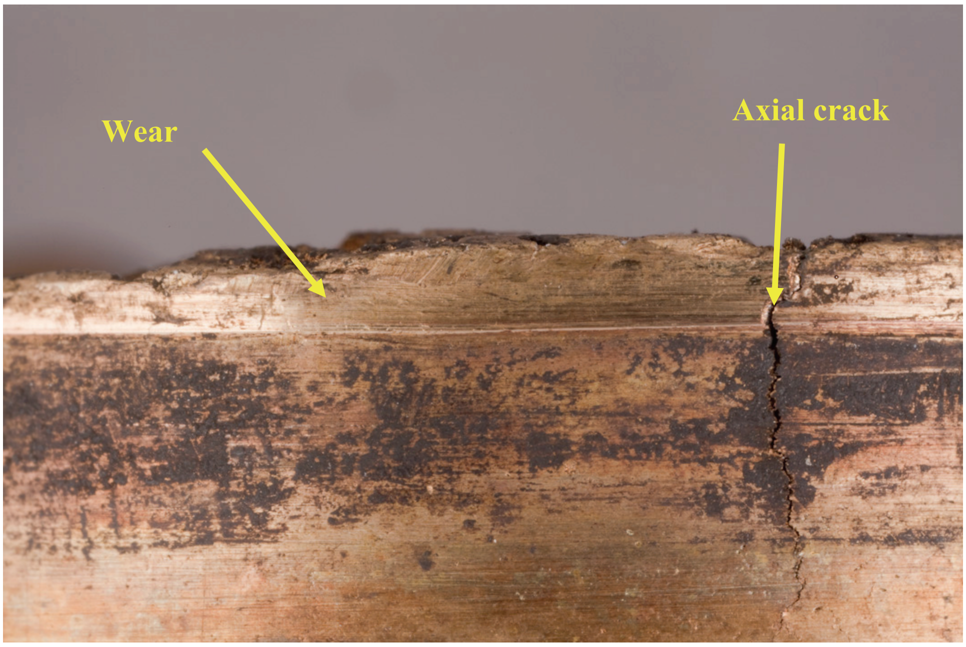

Figure 4

View of bearing outer surface, showing crack and wear mark

approximately one-third of the circumference; this was still evident after being cleaned. A detailed visual inspection revealed the presence of a crack in a corner of one of the keyways within the stained region of the fracture. This had propagated through the wall thickness of the bearing and extended axially for approximately 5 mm. The crack is just visible in Figure 3, with a further view of it on the outer wall of the bearing in Figure 4. There was also a step in the fracture, close to one end of the clean region, as shown in Figure 3.

The crack progression ran from top to bottom (Figure 4), so the crack origin was likely to be in the missing flange portion of the bearing. The wear band extended around approximately one third of the bearing circumference and was coincident with the stained region on the fracture surface. (Note: The outer surface of the bearing is in contact with the inner surface of the bearing housing, within which it rotates, during operation.)

Scanning Electron Microscope (SEM) examination of the fracture surface

Sintered bronze is manufactured via a powder metallurgy process using an elemental mixture of primarily copper and tin. This involves heating to a temperature below the melting point of copper but above that of tin, resulting in a bonded alloy. However the individual particles remain identifiable within the microstructure, such that sintered material has a high porosity, typically 20-25%. For bearing applications the pores are filled with lubricant, usually under a vacuum. The helicopter manufacturer stated that the bearing material specification was oil-impregnated AMS 4805.

The SEM examination revealed different features between the fracture surfaces of the stained and clean regions. Whilst the fracture was intergranular (ie following the surface of the powder particles) in both cases, ductile dimples, consistent with overload failure, were visible in patches in the clean areas, where adjacent particles had bonded. In contrast, the fracture surface within the stained region was masked by corrosion products, with an absence of ductile dimpling. There was insufficient evidence in this area to determine the mode of crack growth. Photographs of the fracture surfaces of the two regions are shown in Figures 5a and 5b.

Energy dispersive X-ray (EDX) analysis was carried out within the stained region of the fracture to determine the elemental composition of the corrosion deposit. This revealed the presence of chlorine, which is corrosive to bronze. A comparative analysis conducted on the clean area revealed that the main elements present were copper, tin and iron, which is consistent with AMS 4805. It was concluded that the chlorine was likely to have come from atmospheric moisture.

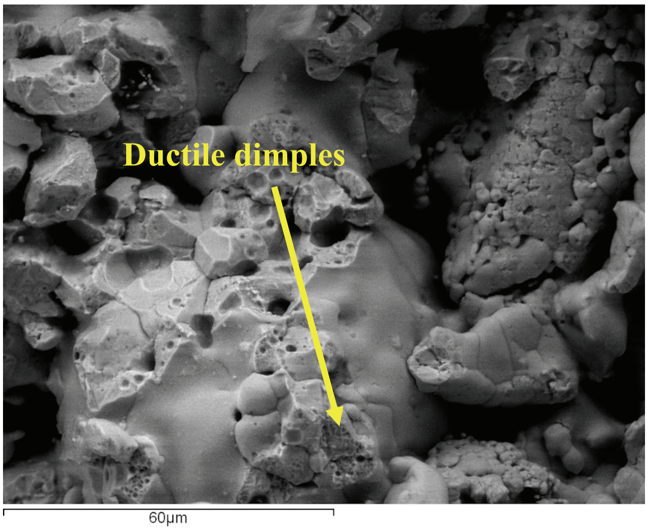

Figure 5a

Fracture surface in clean area

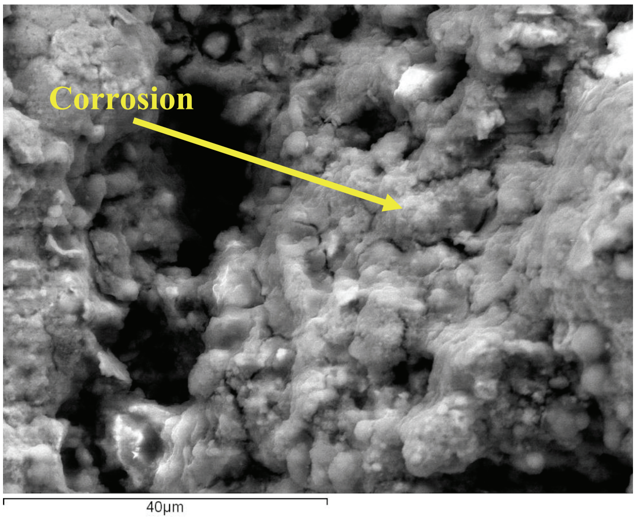

Figure 5b

Fracture surface in stained area

Finally, an assessment was made of the density and porosity of the bearing material. The dimensions of a small piece of the material was accurately measured and weighed. A further check was conducted by means of the measurement of displaced water which led to figures of 6.21 and 6.25 gm/cm^3 respectively. The porosity was assessed by measuring the areas of void on a polished cross section and this was determined to be 31%.

Other information

According to the helicopter's maintenance organisation, G-OJMF had achieved 570 operating hours since new (in 1999) and was parked outside at its operating base. No significant corrosion problems were reported, although an area of corrosion had developed on the tail rotor drive shaft, as can be seen in Figure 1.

The maintenance organisation confirmed that the tail rotor blades were the original components, as fitted at build. There was no record of any disturbances to the tail rotor assembly, other than normal servicing.

Discussion

The available evidence indicated that the tail rotor pitch change bearing had suffered an in-flight failure, in which an integral flange at the inboard end had detached. The flange normally abuts the inboard shoulder of the ball bearing assembly and is thus pulled along the tail rotor drive shaft in an inboard direction in response to a left yaw pedal demand. The absence of the flange would result in the remaining part of the bearing (which is pinned to the pitch control link) being left at a location on the shaft defined by the aerodynamic/dynamic neutral position of the tail rotor. However, a right yaw pedal input would cause the outboard shoulder of the ball bearing assembly to push directly on the pitch control link, thereby changing the pitch of the blades. This scenario accords with the pilot's report of being able to yaw the aircraft only to the right.

The bearing failure is likely to have had its origin in a crack that initiated somewhere on the flange. This progressed in an outboard direction, along the line of a key slot, before branching in a circumferential direction. It was not possible, in the absence of the flange fragments, to determine why the crack occurred. Sintered bronze is specified for its suitability for use in bearings and, in this application, is unlikely to be subjected to significant axial loads. An event such as a tail rotor strike could have resulted in bearing damage but since the rotor blades had not been changed since new, this was discounted. Additional possible explanations could include a material flaw, or an excessive load resulting from a violent yaw pedal input. The latter seems improbable unless there was a resistance arising, for example, from the inner race of the ball bearing assembly becoming temporarily seized to the pitch change bearing due to corrosion following a period of inactivity.

The aircraft had averaged around 50 flight hours per year and was hangared outside so corrosion related problems might be expected. Regardless of the causes of the crack initiation, corrosion featured in the crack progression. The metallurgical examination suggests that approximately one-third of the bearing circumference was cracked prior to the incident flight. The other two-thirds of the fracture was consistent with ductile overload and exhibited little evidence of corrosion, suggesting that this fracture had been a more recent event, probably occurring during the incident flight. The step observed within the overload region of the fracture is most likely the result of two crack fronts, propagating on different planes, coming together. Overload cracks are likely to have propagated from either end of the stained region, travelling in opposite directions around the bearing until meeting and causing the step.

The wear band that was visible over part of the external wall of the bearing, adjacent to the fracture, was also difficult to explain, although is possible that it occurred following the flange detachment, which resulted in some rotational eccentricity.