ACCIDENT

Aircraft Type and Registration:	Rotorway Executive 162F, G-FLIT
No & Type of Engines:	1 Rotorway RI 162F piston engine
Year of Manufacture:	1998 (Serial no: 6324)
Date & Time (UTC):	26 August 2012 at 1315 hrs
Location:	Near Haslemere, Surrey
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to tail rotor blade tips
Commander's Licence:	Private Pilot's Licence
Commander's Age:	72 years
Commander's Flying Experience:	536 hours (of which 365 were on type) Last 90 days - 4 hours Last 28 days - 1 hour
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

Whilst in the cruise, the helicopter suddenly yawed and the engine rpm increased rapidly. The pilot closed the throttle and entered an autorotative descent. The subsequent landing was achieved with only minor damage to the helicopter. It was found that the loss of drive to the main rotor system was caused by the fatigue failure of a drive shaft. There was a history of shaft failures on this helicopter type, mostly involving an earlier design; this aircraft was equipped with the latest design standard.

Circumstances of the accident

The aircraft was returning from Dunsfold to a private landing site near Petersfield, and was on a track of around 250º at an airspeed of 70-80 mph. Due to a headwind, the groundspeed was around 60-70 mph, which had encouraged the pilot to maintain a relatively low altitude of around 1,000 ft. As the helicopter neared rising ground near Haslemere the pilot turned towards the south and started to climb. Without warning, the helicopter yawed violently and the engine rpm rapidly increased, entering the red sector of the tachometer. The pilot estimated that within 2 seconds he had closed the throttle and set up the helicopter for autorotation. However, as a result of a late initiation of the climb, the aircraft was at a height of only 700-800 ft agl. This limited the time available to choose a landing site and, with only a few seconds before it was necessary to flare, it became apparent that the surface of the selected field was uneven. As a consequence the helicopter landed on an upslope, with the uneven surface resulting in the tail rotor contacting the ground. However the pilot was uninjured and there was no other damage.

The investigation

It subsequently became apparent that there had been a failure of the secondary driveshaft, such that the engine was no longer driving the main rotor. The drive-train components of the helicopter are illustrated in Figure 1.

The vertically orientated engine drives the secondary pulley, via a set of 'V' belts. This rotates on the secondary shaft which has the tail rotor drive pulley at its lower end and a sprocket assembly, which drives the main rotor via a triple chain assembly, at its upper end. It can be seen that the location of the failure resulted in an immediate loss of drive to the main rotors, although the tail rotor continued to be driven until the pilot closed the throttle, thus activating the free-wheel system.

Figures 2 and 3 show a diagram of the secondary shaft assembly, together with a photograph of the failure. It can be seen that the failure occurred adjacent to the lower edge of the inner race of the upper bearing. The components were returned to the manufacturer in the USA, where the shaft, which is solid, was subjected to a metallurgical analysis. Figure 4 shows the two shaft halves following removal.

The examination indicated that the fracture occurred as a result of rotational bending fatigue, with area of the fracture origin and the final overload failure indicated in Figure 5. The surface of the shaft adjacent to the fracture showed evidence of mechanical wear in comparison to the surface finish elsewhere on the shaft; a photograph of this is also shown in Figure 5. It can be seen that the region was coincident with the location of the upper bearing, with the fracture occurring close to one end of it. The longitudinal scores were on top of the circumferential wear and are likely to have occurred during bearing removal.

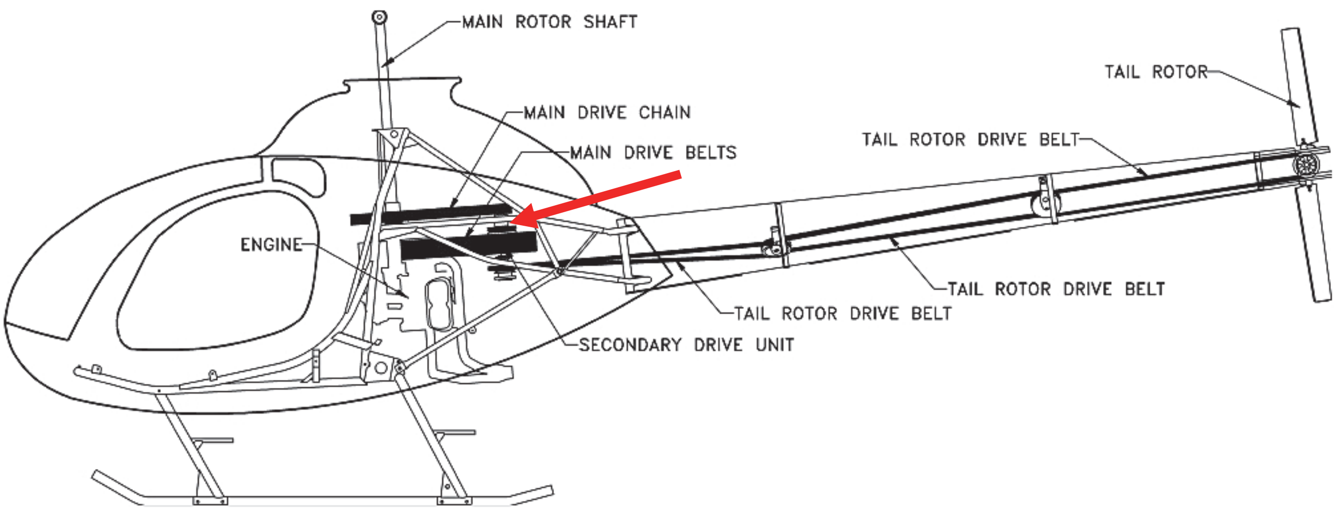

Figure 1

Main components of the drive-train, position of shaft failure arrowed

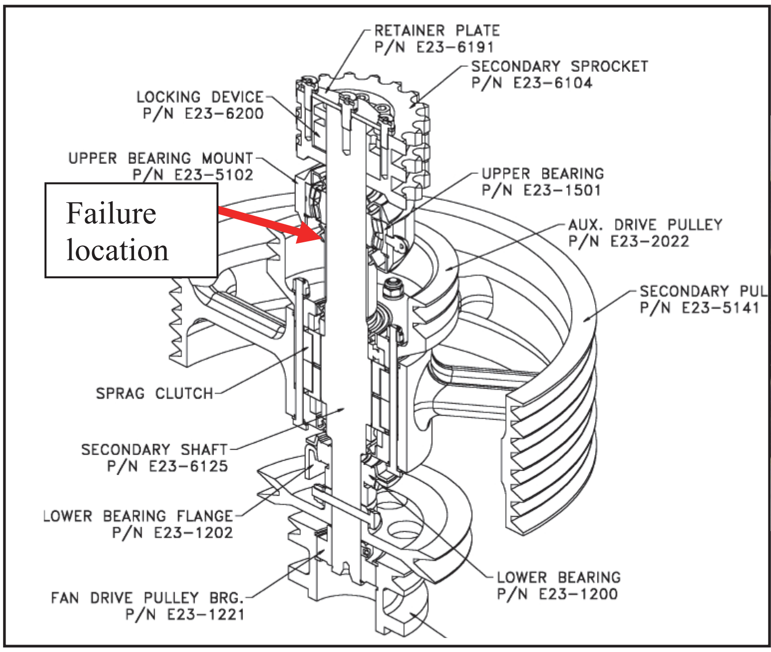

Figure 2

Diagram of shaft assembly

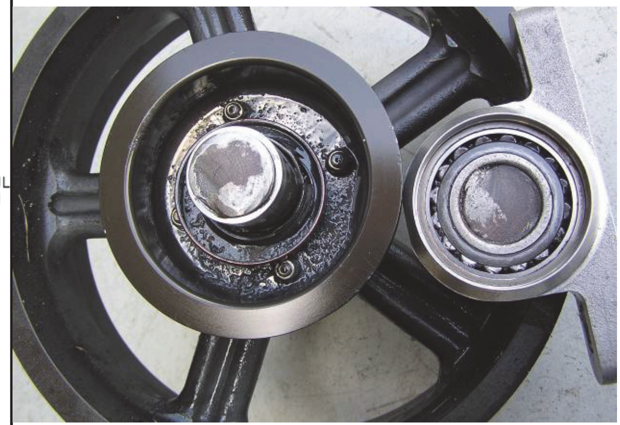

Figure 3

Pulley and bearing, showing both fracture faces of the failed shaft

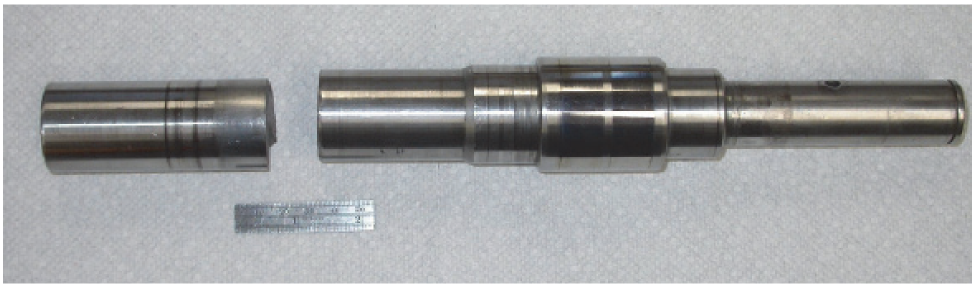

Figure 4

The two pieces of the shaft after removal from the aircraft

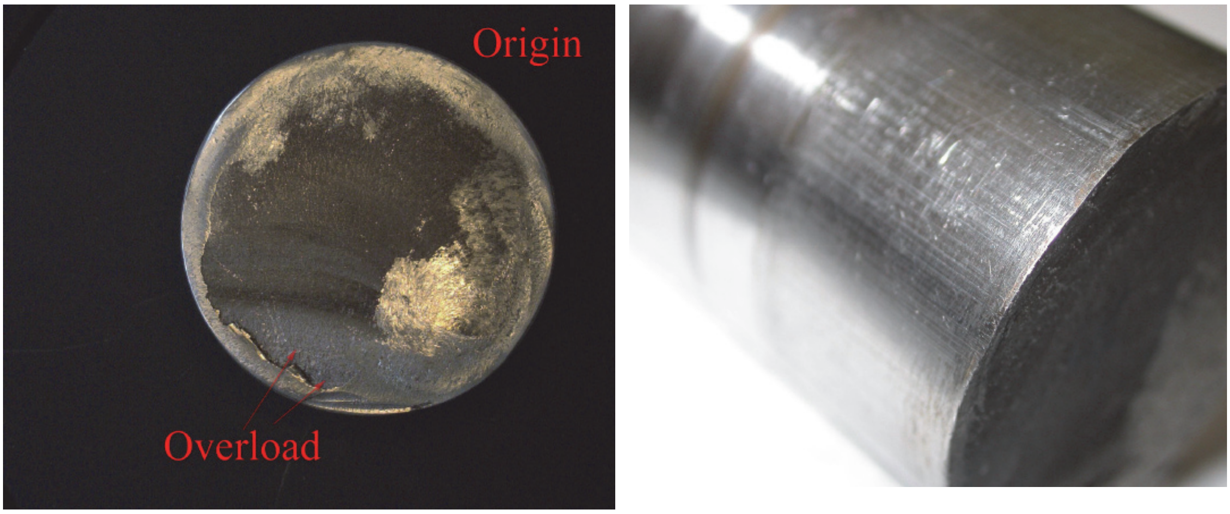

Figure 5

Photographs of the fracture face and smeared surface close to the fracture origin

The metallurgical report indicated that the area of wear was consistent with a fretting process which, in the region of the fracture origin, was associated with missing flakes of metal. The report additionally indicated that this may have induced a fatigue crack. No material defects were observed either in the origin or in the microstructure.

Other information

The 35 mm diameter secondary shaft was introduced on new aircraft in 2001 and replaced a similar design of 30 mm diameter, which had experienced a number of failures. Two failures of the new design, at low operating hours, occurred during that year, with the causes associated with misalignment during installation. The only other recorded failure was that which occurred to G-FLIT, with the shaft having achieved 248 operating hours.

The upper bearing, into which the secondary shaft is located, constitutes a critical part of the drive-train in that any misalignment could result in a significant radial load on the bearing (and in consequence, a once-per-revolution bending load on the shaft). The bearing is lubricated via a grease nipple and can become hot during normal operation, especially when new and immediately after lubrication. The bearing casing has adhesive temperature indicators and is additionally monitored by means of a temperature sensor connected to a cockpit gauge. In the case of G-FLIT, there was no report of unusually high temperature indications prior to the failure, although the pilot commented that moderately high temperatures had been observed during the 'running in' period shortly after installation of the shaft. The pilot also commented that the fretting or spalling marks on the shaft surface were often observed on this type of helicopter.

No problems were observed with the bearing itself.

Discussion

The drive shaft failure was found to be the result of a fatigue crack that initiated close to the location of the upper bearing. The failure was similar in nature to those that had occurred to an earlier, smaller diameter shaft, as well as two apparently isolated occurrences involving the new 35 mm shaft. The metallurgical examination of the shaft from G-FLIT indicated that the fatigue may have initiated in a region of fretting on the shaft surface, close to the point where it emerged from the lower face of the upper bearing. The experience of previous shaft failures indicates that the installation is susceptible to misalignment. The evidence of fretting-plus-bending fatigue failure suggests that an element of misalignment featured in this incident. However, although there may be scope for additional development of this part of the drive-train, the larger diameter shaft represents an improvement in service experience in comparison with the previous version.