ACCIDENT

Aircraft Type and Registration:	Cessna R182 Skylane RG, G-BOWO
No & type of Engines:	1 Lycoming O-540-J3C5D piston engine
Year of Manufacture:	1978
Date & Time (UTC):	6 October 2007 at 1600 hrs
Location:	Wolverhampton (Halfpenny Green) Airfield, W Midlands
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 2
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to left main landing gear and tailplane
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	45 years
Commander's Flying Experience:	2,463 hours (of which 25 were on type) Last 90 days - 46 hours Last 28 days - 15 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and metallurgical examination of components

Synopsis

The aircraft landed with the left main landing gear not fully down. Metallurgical examination showed that this was due to the separation of the landing gear pivot assembly which had resulted from a cyclic fatigue mechanism. There is a history of similar failures on the R182 and the 172RG which share a similar, but not identical, design of the pivot assembly to that on G-BOWO.

History of the flight

The aircraft was approaching Wolverhampton following an uneventful flight when the pilot selected the landing gear down. However, he did not receive a green 'down and locked' indication. He re-cycled the landing gear several times, but to no avail. He then performed a low fly-past of the ATC tower and was informed that the left main landing gear was not fully down. He attempted to lower the landing gear using the manual hydraulic pump and attempted 'energetic' manoeuvres in roll and pitch in an attempt to dislodge the gear, all without success.

Having briefed the passengers, the pilot carried out a landing on the grass Runway 10; the aircraft continued in a straight line until the left wing began to drop and the aircraft then departed to the left, coming to rest on the side of the adjacent tarmac Runway 10.

System description

The aircraft has a hydraulically actuated, retractable, tricycle landing gear system; each landing gear leg is individually actuated by a hydraulic actuator supplied by an electrically operated hydraulic power pack. When the landing gear is selected DOWN, hydraulic pressure causes a rotary actuator to operate a pivot assembly via a splined shaft, and each main landing gear strut rotates forward and outboard (see Figure 1). Once the landing gear has locked down, microswitches for each gear leg trigger a respective green light in the cockpit, and the gear selector returns to the neutral position.

An emergency hand pump is available for emergency extension of the gear. A nose landing gear squat switch prevents inadvertent retraction whenever the nose gear strut is compressed.

Recent maintenance history of the aircraft

There had been a reported loss of hydraulic fluid from the right brake for some weeks prior to the accident, but no cause had been identified. Following recovery of the aircraft after the accident, the actuator assembly was removed, which revealed the surrounding area to be awash with brake fluid. There was no hydraulic leak from the landing gear actuators.

In September 2006 G-BOWO experienced a hard landing on the nose landing gear in gusty wind conditions, which was reported in AAIB Bulletin 12/2006, file ref EW/G2006/09/02. Damage was reported to be limited to the collapse of nose landing gear and damage to the propeller. No inspection was carried out on the main landing gear pivot assembly.

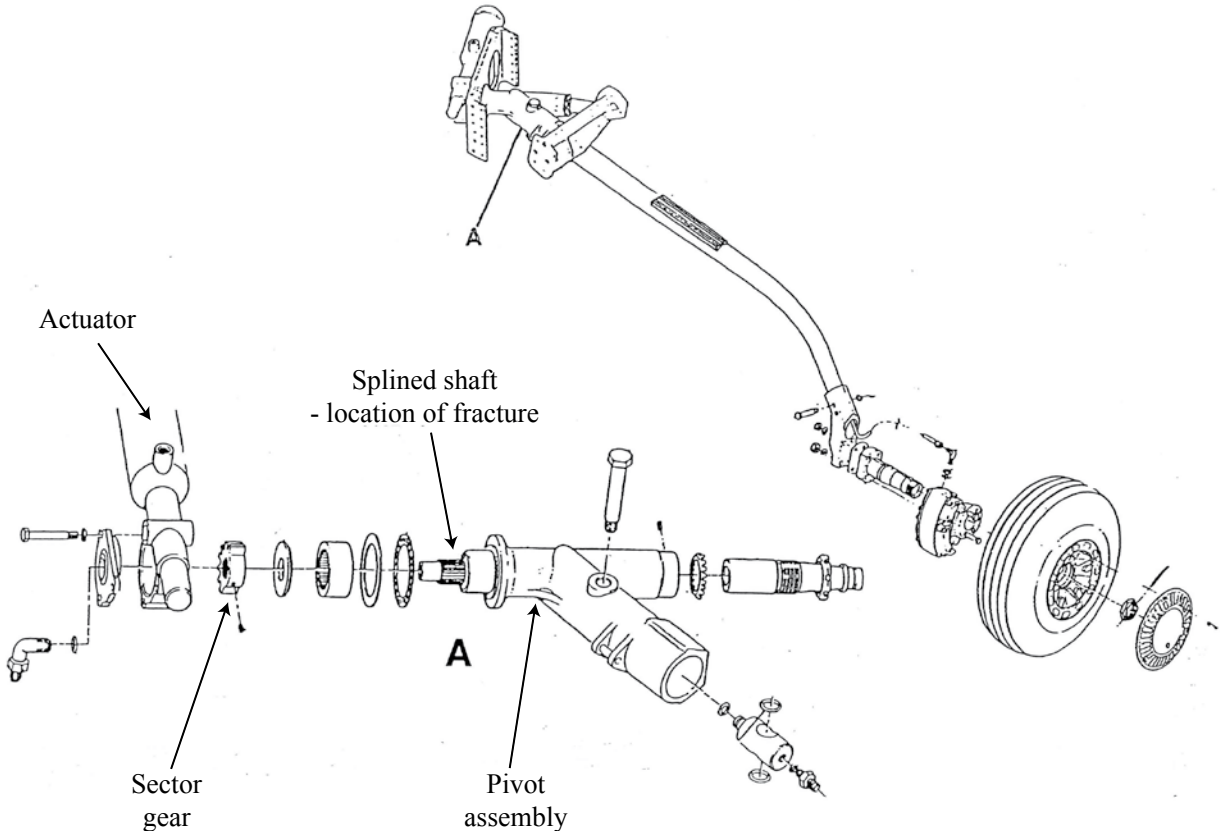

Figure 1

R182 Main landing gear pivot assembly

Metallurgical examination

The detached pivot assembly was returned to AAIB for metallurgical examination. The pivot assembly had separated in the area of the splined shaft. The fracture surface had been partially damaged by smearing during rotational movement, most likely caused during the repeated attempts to operate the gear prior to the landing. A number of fatigue fracture initiation sites were found at the edge of the fracture face, adjacent to a lubricating hole (see Figure 2). The examination concluded that the separation of the pivot assembly had resulted from a cyclic fatigue mechanism during normal functioning of the landing gear in service.

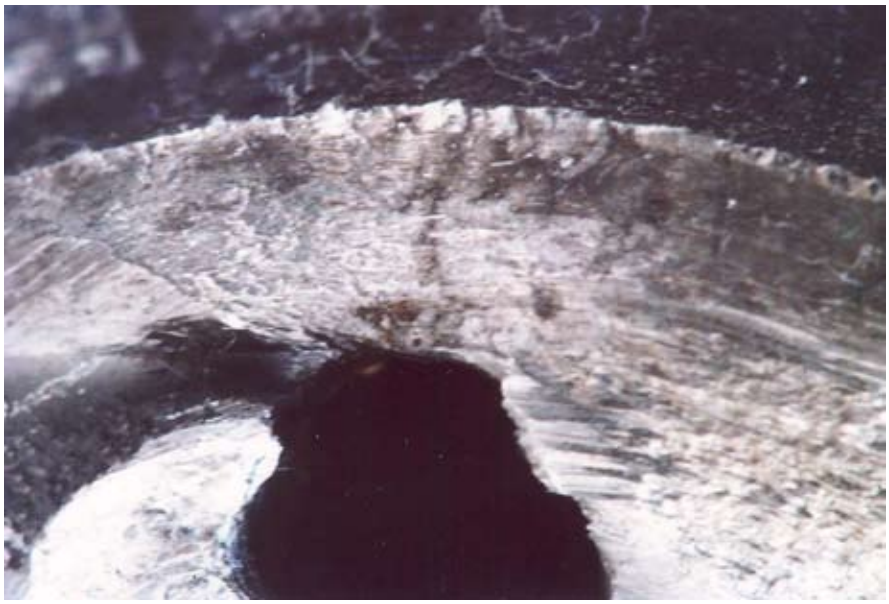

Photo – HT consultants

Figure 2

Edge of the fracture face adjacent to the lubricating hole which, although smeared, shows multiple fatigue initiation sites resulting in castellations

Previous safety action

A Service Bulletin (SB), reference SEB90-1 and entitled '*Main Landing Gear Pivot Inspection*', was published in 1990. It is applicable to the Cessna 172 and 182 models with retractable landing gear, for which the pivot assembly design is similar, however G-BOWO, Serial Number R18200146, was amongst a number of R182 aircraft not affected by the SB. The SB required inspection of the main landing gear pivot for cracks in the spline area; replacement pivots were available which were designed with an improved fatigue life. The SB also states that:

> *'this inspection must be repeated any time an airplane has experienced a landing gear overload condition or if the brakes have a "spongy" operation that cannot be attributed to brake component wear or improper servicing.'*

An accident occurred in 1991 to a Cessna Model 172RG, N9592B which made an intentional wheels-up landing at DuPage Airport, West Chicago, Illinois following repeated unsuccessful attempts to lower the landing gear. Metallurgical examination by the National Transportation Safety Board (NTSB) showed that:

> *'the splined aluminium shaft on the right main landing gear pivot assembly had failed in torsional overload. Cracks were observed at the roots of many of the spline teeth and were observed to have propagated a significant distance into the shaft.'*

The NTSB found that there have been a significant number of Service Difficulty Reports (SDRs) on the Cessna Model 172RG which indicated two failure modes related to the cracking or fracture of the pivot assembly shaft. They were, firstly, the loss of braking action or brake fluid due to cracks in the pivot assembly shaft, and secondly, mechanical separation of the pivot assembly due to the failure of the spline shaft. Several SDRs had also been submitted regarding spongy brake

operation or loss of brake fluid in R182 aircraft due to cracked pivot assemblies. At that time on the R182, none of the cracks were related to accidents or incidents and there were no reports of failure of the main landing gear due to the fracture of the splined shaft. The view of the NTSB then was that the pivot assembly for the 172RG:

> *'is not adequate for long term service and that the design on the new pivot assembly's splined shaft should be changed to improve its structural integrity.'*

Three further SDRs were raised on R182 aircraft, in 1996, 2001 and 2002; all had cracked pivot assemblies and brake fluid leaks which were found during maintenance.

The NTSB issued two safety recommendations to the Federal Aviation Administration (FAA) in 1993. They recommended that the FAA issue an Airworthiness Directive (AD) to mandate Cessna SB SEB90-1 on Cessna Model 172RG aircraft with main landing gear pivot assemblies which have been in service for 2,000 hours to more, or which have been subjected to excessive side loads or other hard landing conditions (A-93-74). Secondly, NTSB recommended that the FAA should require Cessna Aircraft Company to change the design of the splined pivot shaft in order to improve its structural integrity and durability (A-93-75).

The FAA responded to the two recommendations in 1995 having completed an investigation into these failures. They conducted numerous cyclic tests using the original pivot assembly forging and the new improved forging; they reported no failures in 900,000 cycles. The FAA did publish a General Aviation Airworthiness Alert in Advisory Circular 43-16 which reminded pilots of the importance of reporting hard landing or other severe conditions, so that proper inspections could be carried out. The NTSB view was that there still a need for inspection of current pivot assemblies and classified the response as *'closed – unacceptable action*'.

In May 2001, the FAA issued an AD (2001-06-06) which mandated Cessna Service Bulletin SEB90-1 at Revision 3 on the 172RG, but not on the R182. Revision 3 introduced a service kit modification for the pivot assembly for the 172RG. For the R182, Revision 3 only required the removal of a bushing to facilitate the inspection if this had not been removed during an earlier inspection; if it had been removed, compliance with Revision 3 was not required. Due to minor design differences, Revision 3 is not effective for all R182 aircraft and G-BOWO, Serial Number R18200146, was one of those aircraft not affected.

Discussion

The metallurgical examination showed that separation of the pivot assembly had resulted from a cyclic fatigue mechanism during apparently normal functioning of the landing gear in service. Fracture of the splined shaft resulted in the separation of the pivot assembly and the gear strut from the hydraulic actuator, making mechanical extension of the landing gear impossible. The limited history of failures on the R182 might support the same conclusion on the R182 as the NTSB had made on the 172RG, ie that the design is not adequate for long term service; however the work done by Cessna and the FAA failed to reproduce the failure mode. Also, the in-service history of G-BOWO raises questions about the exact cause of the failure in this case. Nonetheless, the work done by Cessna and the FAA, as well as this accident, show that it is important for owners and operators to be aware of damage which can result from operation outside the normal operating envelope.