ACCIDENT

Aircraft Type and Registration:	Piper PA-28-161, G-BRBA	
No & Type of Engines:	1 Lycoming O-320-D3G piston engine	
Year of Manufacture:	1979 (Serial no: 28-7916109)	
Date & Time (UTC):	4 September 2021 at 1110 hrs	
Location:	Wycombe Air Park, Buckinghamshire	
Type of Flight:	Training	
Persons on Board:	Crew - 1	Passengers - 1
Injuries:	Crew - None	Passengers - None
Nature of Damage:	Damage to the right landing gear leg, right lower wing skin and right flap	
Commander's Licence:	Commercial Pilot's Licence	
Commander's Age:	56 years	
Commander's Flying Experience:	1,287 hours (of which 998 were on type) Last 90 days - 7 hours Last 28 days - 3 hours	
Information Source:	Information provided by the pilot and further enquiries made by the AAIB	

Synopsis

When the instructor selected landing flaps and reduced speed the aircraft started to handle in an unusual way. It became apparent on landing that the right main landing gear had failed. Both occupants escaped without injury.

The investigation found that the right landing gear torque link upper attachment lugs had failed due to fatigue. Following previous reports of cracking in this location on several related aircraft types, the manufacturer had issued a Service Bulletin describing a regular inspection procedure.

History of the flight

A flying instructor was scheduled to fly a trial lesson with a new student pilot from Wycombe Air Park. The weather was not ideal for a normal trial lesson but the student was keen to fly so the instructor agreed to fly a few circuits. The instructor and student took off from Runway 06L at 1100 hrs with the instructor flying the aircraft. He reported that the takeoff, climb and downwind leg all seemed normal. He turned onto base leg, selected two stages of flap and reduced speed to 75 kt as normal. However, as he did this, he felt something was wrong with the aircraft, which he described as "surging". He initially thought he was experiencing a rough running engine so tried changing fuel tanks, checking the mixture and selecting carburettor heat. He told Wycombe Radio that he had a rough running engine

and continued the approach. However, as he continued, he realised that the engine was running normally but the aircraft still had an unusual “surging” motion.

As the aircraft touched down on Runway 06L it was immediately obvious to the instructor that the right landing gear had failed. He described the landing as a “very gentle touchdown”. He applied left aileron and closed the mixture and, as the aircraft slowed and the right wing dropped, it turned though 180° and slid onto the grass (Figure 1). The instructor made the aircraft safe and helped the student exit the aircraft. Neither was injured.

Figure 1

G-BRBA after the accident

Accident site

Inspection of the aircraft showed that the lower section of the right landing gear oleo had come out of the upper cylinder. The wheel assembly had remained attached to the aircraft by the flexible brake hose. The assembly had become wedged on the back of the right-wing flap (Figure 2 and 3). Abrasion on the brake calliper showed that as the aircraft landed and the right wing dropped, the aircraft slid on the underside of the wedged wheel assembly. The remaining upper portion of the landing gear oleo was undamaged and did not appear to have contacted the runway.

Figure 2

Right wheel assembly and lower portion of the oleo wedged on the flap

The right flap was damaged where the wheel assembly had become wedged on the flap. There were also puncher marks on the underside of the wing where the loose wheel assembly had been flailing below the wing.

Figure 3

Right wheel assembly viewed when the wing was lifted after the accident, showing the taut brake line

Further damage was caused to the lower wing surface during recovery of the aircraft.

Aircraft information

The Piper PA-28 has a fixed tricycle landing gear. Each main landing gear consists of an oleo with a single wheel and brake calliper. The lower part of the oleo is retained within the upper part by a toque link and flexible brake pipe. The torque link also maintains the alignment of the main landing gear wheels. Figure 4 shows the normal assembly (the photograph is of the left land gear of G-BRBA).

There are two types of oleo leg fitted to PA-28's. The original, fitted to aircraft manufactured between 1961 and 1977, used a cast landing gear cylinder. Aircraft manufactured since 1977 were equipped with a forged cylinder. G-BRBA was fitted with the original cast landing gear cylinders. The forged cylinder can be fitted to earlier aircraft.

The original cast cylinders have a history of fatigue cracks developing in the torque link attachment lugs of the upper cylinder. Following previous failures of the lugs, the CAA issued an Airworthiness Directive (AD) requiring the inspection of the landing gear castings for cracks (AD 002-06-99).

Figure 4

PA-28 left main landing gear

On 18 August 2003 the aircraft manufacturer issued Service Bulletin (SB) 1131 providing instruction for the inspection of the oleo lugs at 100-hour intervals. The inspection required the torque link to be removed and the lugs to be inspected visually using a 10x magnifying glass. If no cracks were found the SB required the area to be inspected using liquid dye penetrant. On 18 August 2016, an updated SB (SB 1131A) was issued which added illustrations and further instructions to clarify the inspection procedure. Figure 5 is extracted from the SB and shows the area which required inspection.

On 30 December 2005, the EASA issued AD 2005-0035 which retained and superseded the CAA AD. This AD was cancelled on 20 February 2020. The reasons given for the cancellation were:

> *'1. The service history of the affected aeroplanes with respect to this failure mode (in particular the consequence of the failure in the reported occurrences) and criticality of a main landing gear failure,*
>
> *2. the reduced probability of such failure occurring on the remaining fleet, due to the available improved inspection instructions in Piper SB 1131A, and*
>
> *3. the gradual fleet replacement of cast MLG with forged MLG.'*

The cancellation notice stated that '*EASA has determined that an acceptable level of safety exists and an AD was no longer necessary*'.

The maintenance organisation responsible for G-BRBA reported that the inspection detailed in SB 1131A was completed during the last 100-hour inspection on 10 August 2021 and no cracks were found. Since then, the aircraft had flown 33 hours and completed 110 landings.

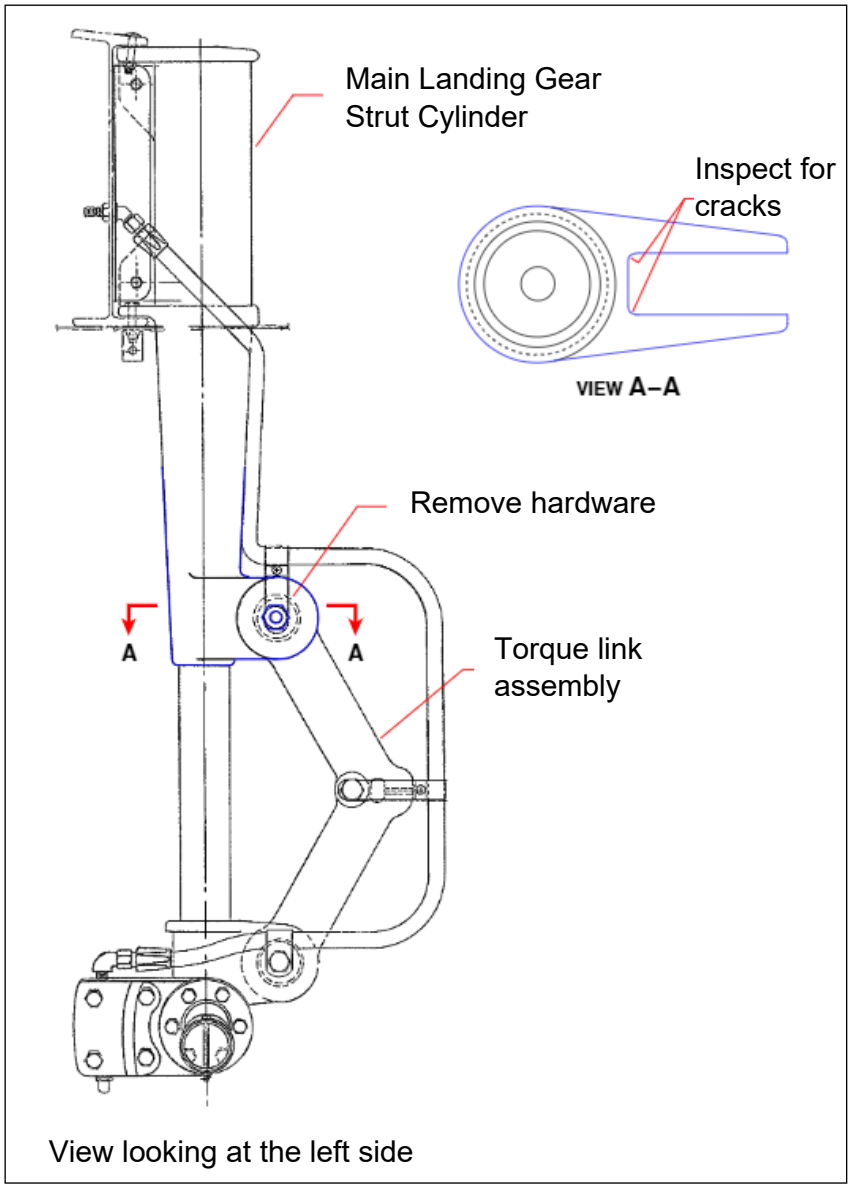

Figure 5

Extract from SB 1131A showing the area requiring inspection

Aircraft examination

Examination of the landing gear oleo on G-BRBA showed that the torque link upper attachment lugs had broken away from the upper cylinder (Figure 6) disconnecting the torque link.

The failed lugs were sent to a metallurgist for a detailed analysis of the fracture surfaces.

Figure 6

Right landing gear assembly showed the failed upper torque link attachment lugs

Analysis of fracture surfaces

The fracture surfaces were examined using a scanning electron microscope. Macroscopic radial markings on the fracture surface indicated that, on each lug, the fracture had initiated at the lower end of the inner radius (Figure 7 and 8). At the locations of fracture initiation, faint crack progression markings indicated the presence of fatigue cracks. The fatigue crack fronts extended inwards from the surface to a maximum depth of 2 mm. The appearance of the remainder of the fracture surface area was consistent with final separation, when the remaining uncracked cross-section became overloaded, due to the advancing fatigue cracks. There was no evidence of pre-existing material or mechanical defects associated with the fatigue crack initiation.

At higher magnifications, fine fatigue striations could be seen within the regions of the fatigue crack growth but they were too numerous for each individual striation to correspond to a single landing. It is therefore likely that they corresponded to both landings and vibrations in the landing gear. It was not possible to identify a pattern or periodicity in the striations that could be correlated to the number of landings.

Liquid penetrant inspection

SB 1131A required an inspection by liquid penetrant if cracks could not be seen with a magnifying glass. Aluminium alloy castings typically have a degree of porosity. Surface breaking porosity often produces a degree of background fluorescence during dye penetrant inspection. In some cases, it can be difficult to differentiate such porosity from very small cracks. The inspections are conducted with the component on the aircraft which can also make it harder to see very small cracks.

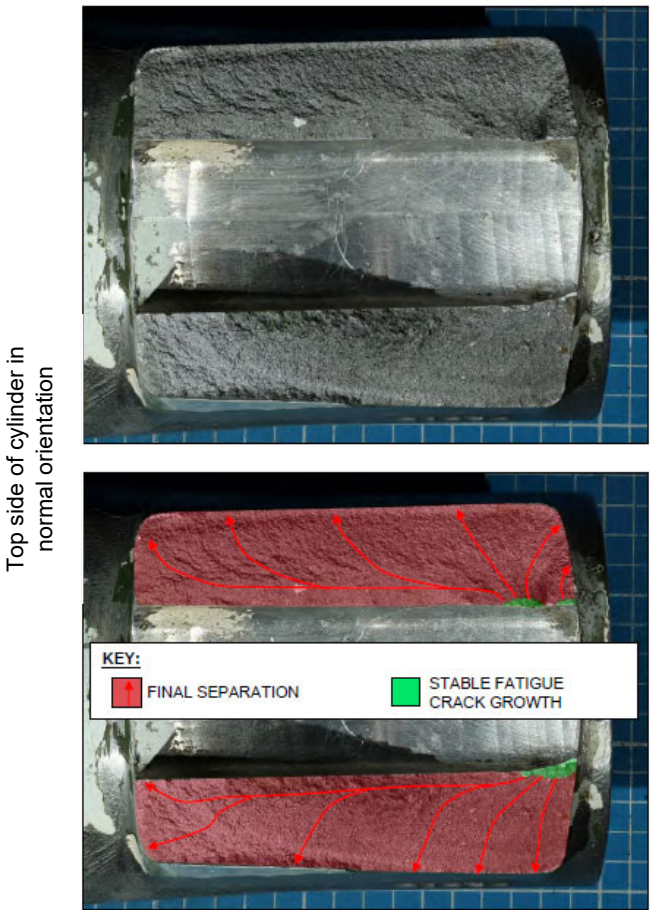

Figure 7

Fracture surface on the landing gear upper cylinder

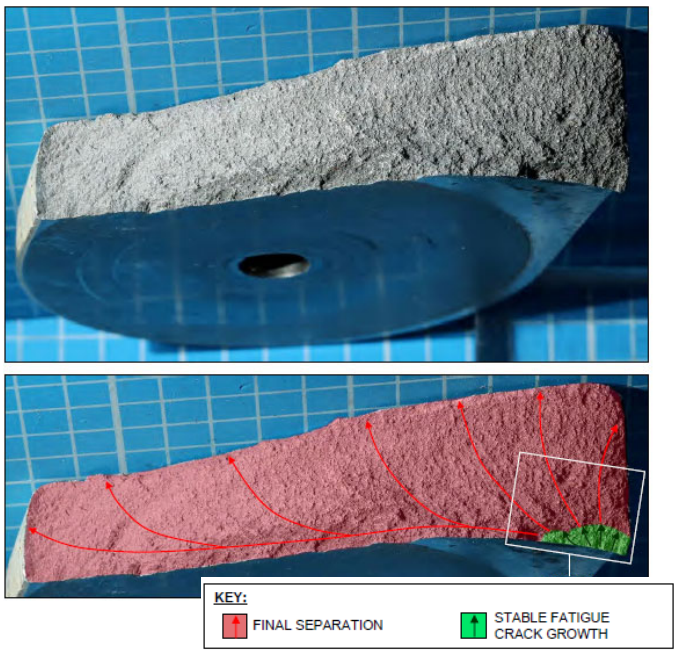

Figure 8

View of the left lug (similar cracks were found on the right lug)

Analysis

The upper attachment lugs of the right landing gear torque link failed allowing the lower portion of the oleo and wheel assembly to slide out, only remaining attached to the aircraft by the brake hose. The lugs could have failed on the takeoff roll or in flight, but it only became apparent to the pilot that something was wrong when he selected flap and reduced speed as the aircraft turned onto base leg.

Analysis of the failed attachment lugs showed that fatigue cracks had formed in the lower inner corner of both lugs and these had grown until they failed in overload. The fatigue crack had grown to a maximum depth of 2 mm prior to the failure. It was not possible to determine how long the fatigue crack had been growing.

The original cast landing gear leg fitted to this and similar Piper aircraft, had a history of fatigue cracking in this location. In 2003 the aircraft manufacturer issued a SB requiring inspection of the lugs for cracks every 100 hours. The CAA issued an AD mandating the SB and in 2005 this was adopted by the EASA but was cancelled in 2020 because the EASA determined that an acceptable level of safety existed.

The SB was completed on G-BRBA during its previous 100-hour inspection (33 hours and 110 landing prior to the accident) and no cracks were detected. It could not be determined if the cracks were present during this inspection and were not detected, or if the crack formed later. It is possible that the crack, if present, was not detected because of background fluorescence caused by surface breaking porosity of the cast aluminium alloy.

The inspection interval is based on hours rather than number of landings. The manufacturer does not require the number of landings to be recorded, so do not specify inspections based on landings. The aircraft had completed 110 landings since the inspection and it is possible that this number of landings was sufficient to allow the crack to develop.

Conclusion

The right main landing gear torque link attachment lugs failed due to fatigue cracking, causing the lower part of the oleo to slide out of the upper part. This component has a history of cracking in this area and a SB exists to regularly inspect the area.

AAIB Comment

This accident shows that fatigue cracking of the torque link attachment lugs continues to occur, and that this can lead to an accident. It highlights the importance that operators of the affected aircraft continue to inspect their aircraft in accordance with the SB. It also suggests that it may be prudent for operators whose aircraft accumulate a significant number of landings to inspect their aircraft more frequently than required by the SB.