AAIB Bulletin No: 11/94 **Ref: EW/C94/6/1** **Category: 1.3**

Aircraft Type and Registration:	Piper PA-34-200T Seneca II, G-BEHU
No & Type of Engines:	2 Continental TSIO-360-E piston engines
Year of Manufacture:	1976
Date & Time (UTC):	1 June 1994 at 1725 hrs
Location:	Beverley Airfield, North Humberside
Type of Flight:	Public Transport
Persons on Board:	Crew - 1 Passengers - 2
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to right aileron and propeller; wrinkling of right wing skin and lower fuselage
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	39 years
Commander's Flying Experience:	2,011 hours (of which about 400 were on type) Last 90 days - 47 hours Last 28 days - 30 hours
Information Source:	AAIB Field Investigation

History of the flight

The aircraft was on a flight from Fairoaks Airport, Surrey to Beverley Airfield, North Humberside. The commander was informed on the air/ground operating frequency that the runway in use was 12 and he positioned the aircraft left downwind for a visual circuit; the surface wind was light and variable and the visibility was reported to have been 5 to 6 nm in light rain. The aircraft was positioned on a 2 nm final approach and the airspeed was reduced to 75 kt as the aircraft crossed the airfield boundary hedge. The commander stated that the touchdown was gentle, about a third of the way down the runway, and the aircraft slowed normally to what was described as a fast taxi speed, when it started to turn slowly to the left; the right main landing gear collapsed as it passed over the runway identifier numbers at the 30 threshold. The aircraft was shut down and occupants vacated it without injury.

Aircraft performance

Examination of wheel tracks on the runway indicated a touchdown point about half way down the runway; a distance of 320 metres was measured between this point and the position where the aircraft eventually came to rest. The wing flaps were found selected to the up position; the lack of damage to

the right flap indicate that they had been up before the landing gear collapsed. It is a common practice on this type of aircraft to select the flap up at some point after touchdown; the commander had no recall of doing this but was confident that the approach had been carried out with land flap selected. The landing distance available on Runway 12 was 639 metres and the runway surface was of short grass which was slightly wet from recent rain. The unfactored landing distance required was calculated to be 627 metres (factored 896 metres) for a dry grass runway; the ground roll portion of this was 375 metres. The slight wetness of the surface would have increased these distances but it was not possible to quantify this.

Commander's experience

The company chief pilot reported that the commander was in the process of being trained, with a view to employment by the company on a freelance basis. A base check with the company's type rating examiner (TRE) on 17 May 1994 did not reach the required standard; AAIB discussion with the TRE revealed that this was related to the instrument approach portion of the check and was attributed to his lack of recent experience rather than any lack of general flying ability. A further base check was planned for the day following the accident. He was, therefore, qualified to fly the aircraft in the private category but not to conduct a public transport flight; also, Beverley Airfield was not licensed for public transport.

Examination of aircraft

During the process of the gear collapse, the right propeller had contacted the ground, leaving three distinct blade slashes in the ground. The orientation and spacing of these marks indicated that the aircraft had been pointing 70° to the left of the runway heading, and had been moving at a speed of approximately 16 mph, assuming the engine had been idling at 700 RPM. Following the collapse, the aircraft yawed to the right as the outboard section of the right wing contacted the ground.

The wheel tracks did not reveal any evidence of a heavy landing or significant skidding, and the left turn that preceded the collapse did not appear to be sharp enough to induce lateral skidding.

The aircraft was lifted and a trestle placed under the right wing. When the right landing gear was pulled into the down position, it was found that the downlock mechanism, which holds the two halves of the side brace linkage in an overcentre position, had broken. In addition, the actuator ram had been pushed approximately 70% of its travel towards its retracted position in the actuator body before the ram had broken close to its attachment to the side brace link.

Figure 1 shows a diagram of the landing gear. The side brace linkage essentially consists of an upper an lower link, which, when the gear is extended, are held in an overcentre position with the aid of a spring and downlock hook. The retraction process is initiated by the actuator lifting the hook off the pawl, followed by the rotation of the linkage.

When the landing gear was pulled fully down during the recovery, it was noted that there appeared to be a significant amount of free play in the stud/bushing assembly that attached the side brace to the front spar of the wing, and about which the linkage rotated. It was apparent that any movement in the linkage occurring as a result of the free play would reduce the overcentre and hence increase the risk of the geometric lock breaking and the landing gear collapsing. A lesser amount of play was also observed in the same components on the intact left landing gear. The studs and bushings were located in machined alloy bracket assemblies which were bolted to the wing spar. Once the aircraft had been ferried to its repair station, the components from both main landing gears were removed for examination by the AAIB. It is not known how long these components had been fitted to this aircraft.

The stud (Part No 95299-02) from the right-hand side was found to be bent when it was removed from the assembly. The associated bush (Part No 67026-12) is manufactured in two halves, with a space between the two acting as a grease groove. The half-bushing nearest the head of the stud was found to be a very loose fit in the bracket, and had adopted a slightly oval shape, with the bore diameter varying between 0.566 to 0.575 inch. Metallurgical examination revealed that the out-of-round on the outside diameter and the greater part of the out-of-round in the bore was the result of plastic deformation. There was also plastic distortion of the flange of the bush at one position, and this had formed a part-circumferential depression on the edge of the hole in the bracket. The diameter of the hole varied between 0.753 to 0.766 inch, with plastic deformation being responsible for the variation. It was therefore concluded that the condition of the assembly was the result of an overload such that could have occurred in a heavy landing.

When the right-hand stud was reassembled into the bush and bracket, the deformation was such that it could only be rotated a limited amount from the as-found (ie gear down) position. There was no evidence that it had rotated to the extent required for gear retraction since the plastic distortion occurred. This suggested that the distortion had been occasioned either on the last landing or on an immediately preceding one.

Examination of the studs revealed that both of them contained evidence of poor machining and corrosion in the blend radius between the head and shank. The corrosion had occurred before the studs were last cadmium plated. In addition, they both contained fatigue cracks in this area. The cracks were examined in detail after the studs were sectioned longitudinally. It was found that the right-hand stud was cracked to a total depth of 0.013 inch on the concave side of the bend in the shank. It was apparent that the crack had developed to a depth of 0.003 inch before being relieved plastically by overloading. The crack had then progressed, in fatigue, to the full depth of 0.013 inch. It was considered that the overload condition must have occurred a significant time before the subject incident.

The crack on the convex side of the bend in the shank had progressed to a depth of 0.021 inch. It had then developed into an overload shear tear at an angle of 45° to the crack, during the subject accident. It was thus apparent that the stud itself was in a condition of imminent failure.

Apart from the slackness of the stud in the bush on the left-hand assembly, the overall condition was reasonable. It was considered that the free play was due to wear; however, it was noted that the landing gear Service Tolerance chart in the Service Manual for the Seneca II does not specify wear limits for the assembly. It is in fact listed, along with most other parts of the linkage; simply the tolerance column is left blank. The fatigue crack in the stud had penetrated to a depth of 0.011 inch on the section taken, although it did not extend around the complete circumference.

The AAIB is aware of four previous Piper PA-34 accidents involving main landing gear failures, the most recent occurring to G-BOSD on 18 January 1994 and reported in AAIB Bulletin No 6/94. In these cases the studs failed in fatigue as a result of cracks similar to those found in the components from G-BEHU. All the studs were the smaller of the two types supplied by Piper, being of $^{9}/_{16}$ inch diameter compared to $^{5}/_{8}$ inch diameter as fitted to later serial numbered aircraft. The larger stud is supplied with a one-piece bush that fits in a modified support bracket.

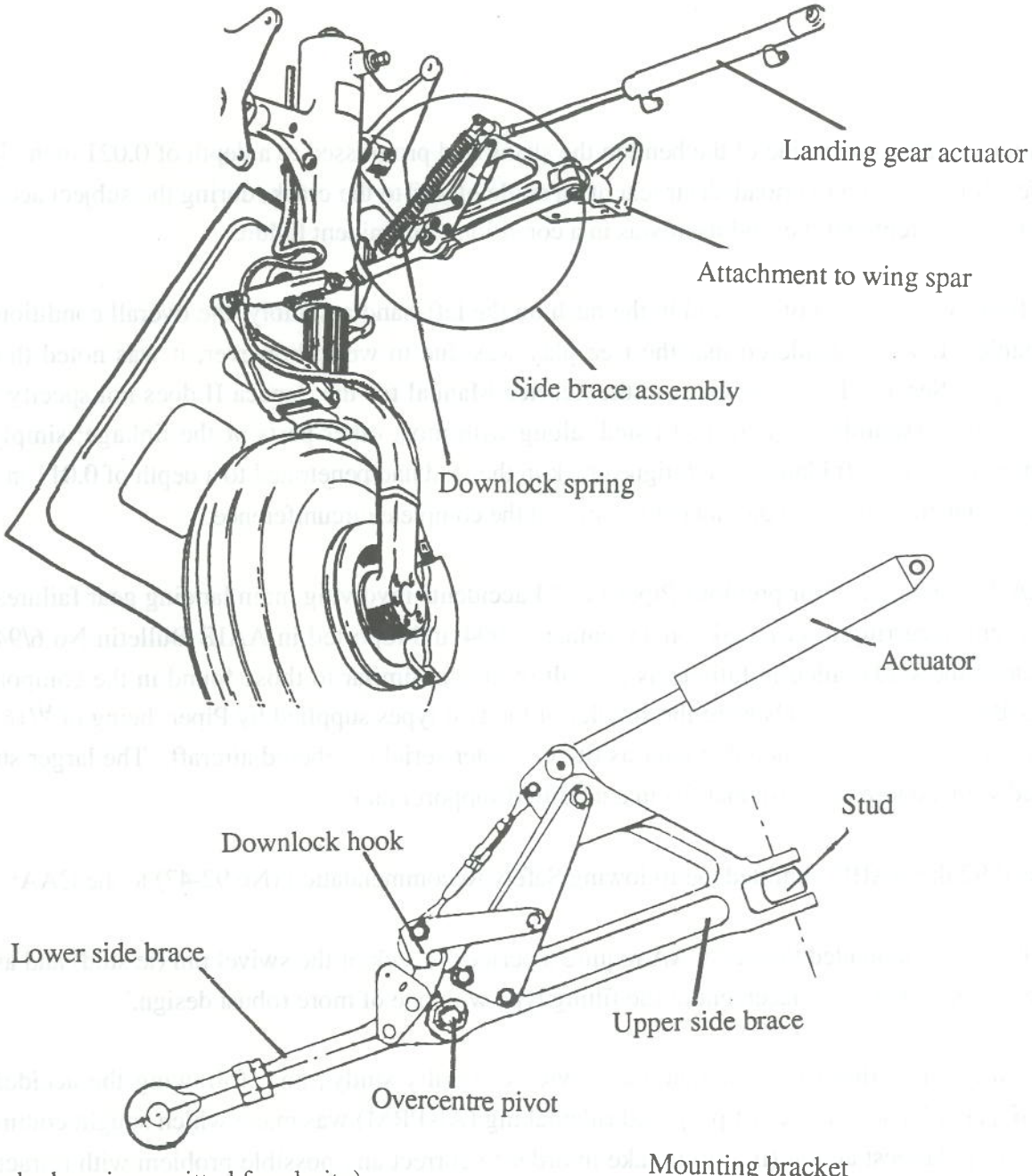
In June 1992 the AAIB submitted the following Safety Recommendation (No 92-47) to the CAA:

'It has been recommended that the CAA require a periodic check of the swivel pin (ie stud) and assess the need for mandatory replacement of the fitting type with one of more robust design.'

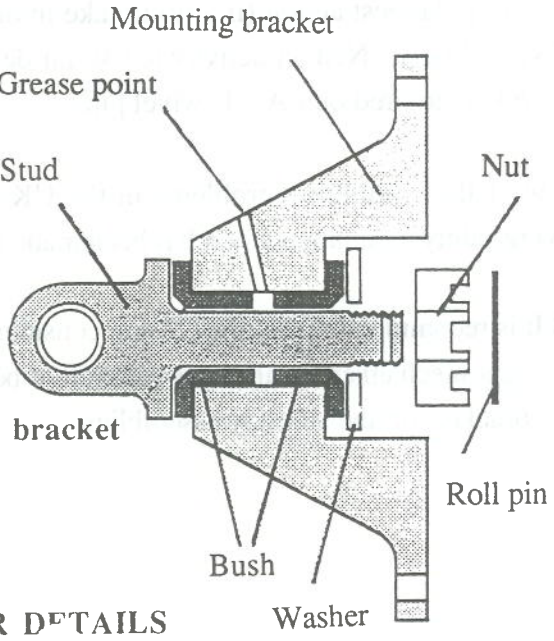
As a result of this the FAA conducted a 'service difficulty study', and, following the accident to G-BOSD, an advanced notice of proposed rulemaking (ANPRM) was made which sought comments '....regarding the best action (if any) to take in order to correct any possible problem with retractable MLG swivel pins.' Neither activity has so far determined that action (in the form of an Airworthiness Directive) is required on PA-34 swivel pins.

In view of the continuing problems in the UK with this area of the PA-34 main landing gear, the following safety recommendation has been made to the CAA:

94-32 It is recommended that the CAA reconsider with the FAA a requirement for the main landing gear mechanism on all PA-34 aircraft to be fitted with the larger diameter studs and modified brackets on the sidestay assemblies.



(Downlock spring omitted for clarity)



Section through stud and spar attachment bracket

FIGURE 1 PA34 MAIN LANDING GEAR DETAILS