SC7 Skyvan 3A Variant 100, G-PIGY

AAIB Bulletin No: 8/2003	**Ref: EW/G2003/01/17**	**Category: 1.1**
Aircraft Type and Registration:	SC7 Skyvan 3A Variant 100, G-PIGY	
No & Type of Engines:	2 Garrett Airesearch TPE331-2-201A turboprop engines	
Year of Manufacture:	1975	
Date & Time (UTC):	22 January 2003 at 1030 hrs	
Location:	South Cerney Airfield, Gloucestershire	
Type of Flight:	Military (parachute training)	
Persons on Board:	Crew - 2	Passengers - 4
Injuries:	Crew - None	Passengers - None
Nature of Damage:	Damage to left main landing gear	
Commander's Licence:	Airline Transport Pilot's Licence	
Commander's Age:	57 years	
Commander's Flying Experience:	8,916 hours (of which 933 were on type)	
	Last 90 days - 37 hours	
	Last 28 days - 4 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot and additional AAIB inquiries	

Synopsis

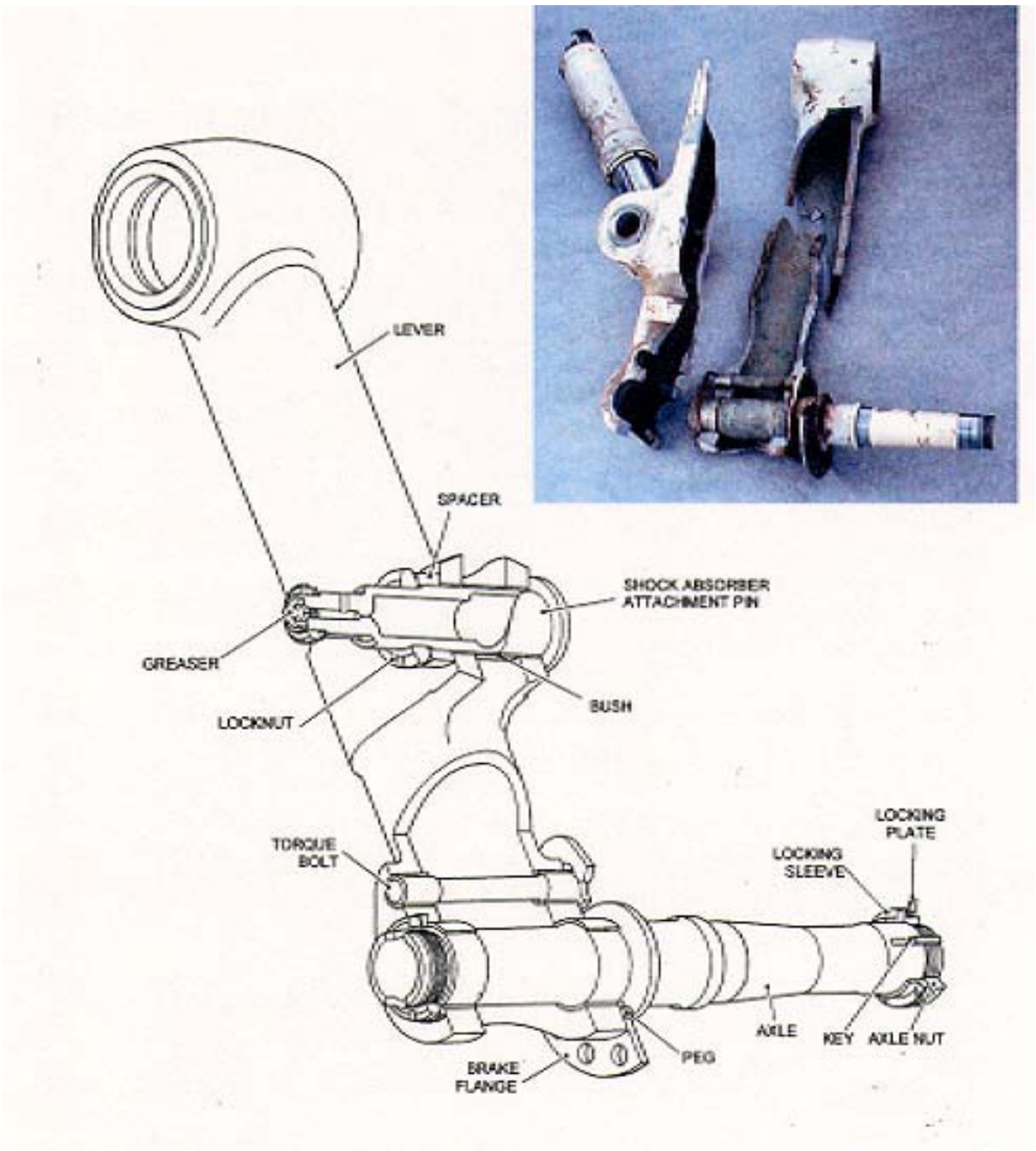
The aircraft had been positioned from its base at Oxford to South Cerney for a military parachuting programme. Two lifts of paratroops were completed uneventfully, the aircraft landing each time into wind on the grass field. However, on landing after the third flight, the left main landing gear collapsed. The aircraft slewed to the left through 120° as it came to a halt, having covered approximately 75-100 metres from the point of collapse. The left wheel, together with part of the leg forging, had separated from the aircraft and was found close by. The four parachute instructors evacuated the aircraft via the rear door, which remained open after the parachute drops. The two crew shut down the aircraft and then vacated it, also using the rear door.

A visual inspection of the landing area revealed no obstructions that could have accounted for the failure of the leg, although a number of significant ruts were observed, these reportedly being due to heavy military vehicles that periodically used the airfield.

Examination of the landing gear lever

The main landing gear on this type of aircraft consists of a trailing arm radius lever attached to the fuselage mounting point at its upper end, and with the wheel axle at its lower end. A shock absorber

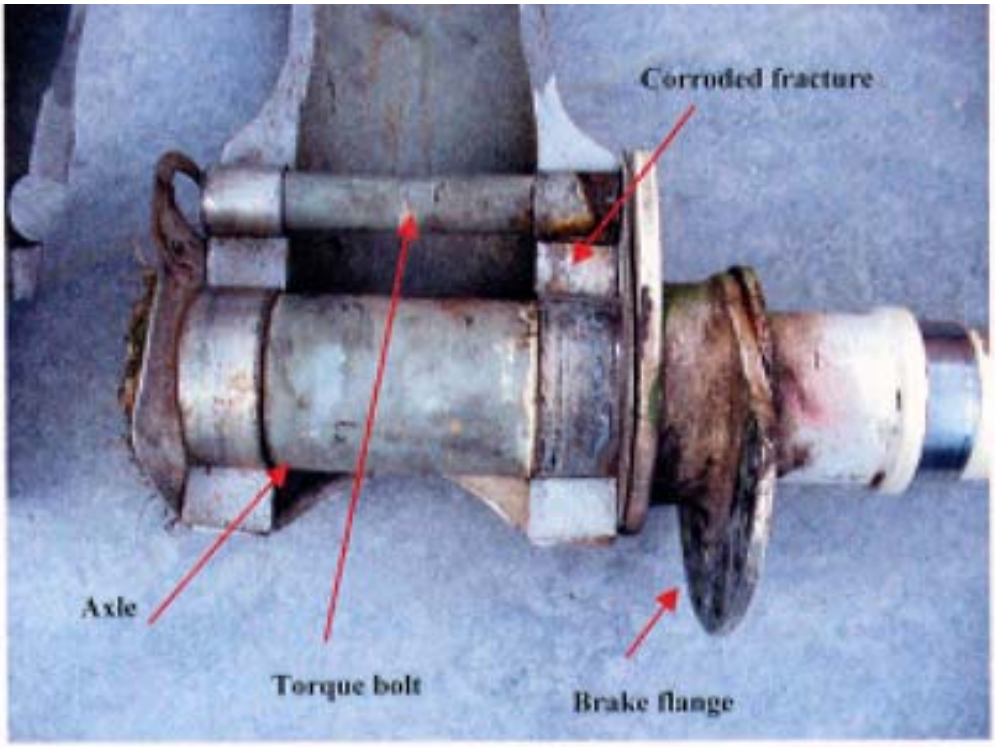
strut is attached to the lever forward of the wheel axle, with the opposite end being mounted on the fuselage. The wheel brake assembly is attached to a flange on the axle, with the brake reaction loads being transmitted to the lever by means of a torque bolt that passes through the leg above and parallel to, the axle. The salient features are shown in the diagram at Figure 1.



(Note: for clarity, the lever is shown sectioned at lower end. By coincidence, the failure occurred along the plane of section, as seen in the inset photograph.)

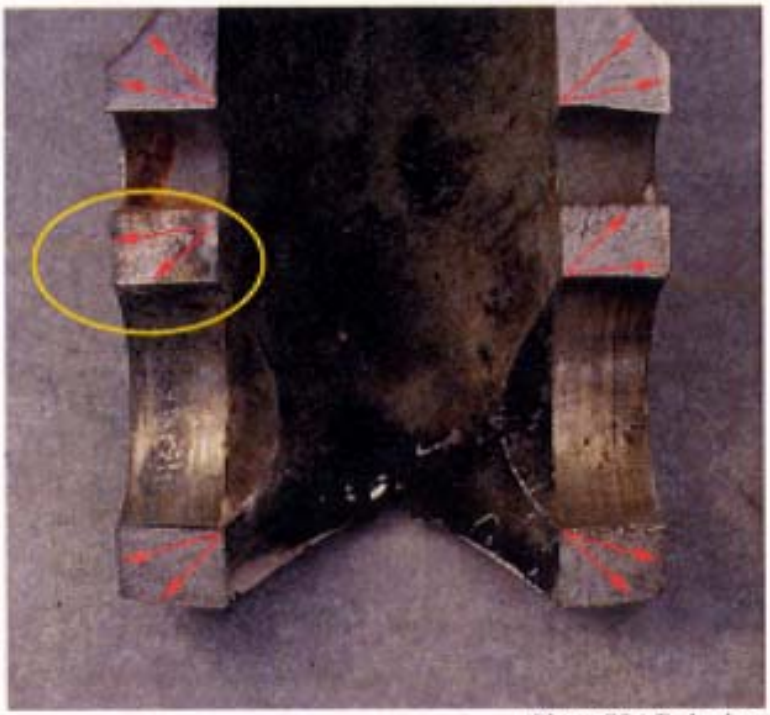
FIGURE 1 Left landing gear lever, - (viewed from underside and inboard)

A metallurgical examination of the lever revealed that the fracture had occurred in the plane of the axle and torque bolt, corresponding to the cut-away section in Figure 1 but extending further along the lever. The surface of the fracture between the axle and torque bolt, on the side nearer the brake flange, was coated with corrosion products and had clearly occurred a considerable time before the other fractures, which were clean and bright in appearance (see Figure 2). Evidence of fretting was apparent on the contact surfaces of the axle and torque bolt with the lever. All the fractures showed clear 'river markings' indicating the position of their initiation and the direction of propagation of each individual crack (see Figure 3) and it could be seen that the origin and direction of the corroded fracture differed from the pattern set by the others. After cleaning and examination using a scanning electron microscope, it was found that the initiation region of this fracture exhibited a different topography, with the fracture surface following an intergranular path. Adjacent to the bore, the surface was coated with products of corrosion. Beyond the initiation region, the fracture became one of ductile overload, as seen on the other fracture surfaces.



(Photo: ERA Technology)

Figure 2 View of failed landing gear lever



(Photo: ERA Technology)

Figure 3 Initiation and propagation of the various ligament fractures. Corroded fracture (circled) characteristics are different from others

The paint finish in the bore of the lever was examined and found to be highly variable in coverage. In the region of the corroded fracture, the coating contained pinholes and was sufficiently thin to reveal the machining marks. Streaking was present, where the paint had lifted due to corrosion, which was indicative of incomplete cleaning. The landing gear manufacturer stated that, following cleaning, the coating process called for chromic acid anodising, followed by a yellow epoxy primer and a grey epoxy gloss finish. It was noted that the primer paint was missing at intervals, including the area of the fracture initiation. On the opposite side of the bore the paint coating was more uniform, although an area of unpainted surface was found, apparently uncorroded.

It was concluded that the corroded intergranular portion of the initial fracture was the result of a stress corrosion crack, one of several forming on the surface of the internal bore in an area of poor paint protection, and which would see a concentration of stress when the aircraft was parked. It is likely that the inadequate cleaning and paint finish were the critical aspects leading to the failure, since the remainder of the bore would be in the same atmospheric environment and some areas might be subjected to similar stresses. It was thus the combination of corrosion attack and stress concentration that led to the formation of the initial crack, with other areas of poor paint coverage being subjected to relatively lower stresses.

There was no evidence of any progressive crack growth on the later fractures, which appeared to be the result of a single overload event. The final failure could have been assisted by the increasing pressure of the corrosion products forming on the initial fracture and in the torque bolt bore. Finally, the metallurgical examination revealed no evidence of any defect in the material of construction.

The aircraft manufacturer stated that they were unaware of any similar failures having occurred in the Skyvan fleet.

Landing gear history

The aircraft manufacturer stated that the aircraft was originally delivered, to the Mauritanian air force in November 1975, with landing gear levers having different serial numbers to those currently fitted. The serial number of the failed item was DRG/1198/79. The last two digits indicate the year of manufacture, ie 1979. No component record card existed for either of the landing gear levers, (the aircraft manufacturer confirmed that no such documentation was raised for the aircraft when it was built) and no reference to them could be found in the airframe log books. On the subject lever, the presence of a steel plate between the side of the lever and the brake flange indicated that a repair had been carried out at some stage. The plate was effectively a shim that restored the width of the lever after the defect (which could have consisted of corrosion or mechanical damage) had been machined away. The absence of documentation meant that it could not be established where, when and why the repair was carried out. The landing gear manufacturer confirmed that the repair was in accordance with an approved scheme, but there was no record of it having been conducted at their factory. However, the work could have been carried out at one of a number of overhaul facilities around the world. The landing gear manufacturer believed that it was unlikely that they had originally delivered the lever in its repaired state as a manufacturing concession.

The aircraft was imported into the United Kingdom from Luxembourg in 1995 and the current operator's maintenance organisation started looking after the aircraft in March of that year. Due to the absence of information on the landing gear components, these were assigned the same hours and cycles as the airframe, even though the actual values would have been considerably less. At the time of the accident the aircraft had achieved 5,743 hours and 7,377 landings, although prior to the last 6 flying hours, the aircraft had been in storage for nearly two years. At the end of December 1979, the year of manufacture of the left landing gear lever, the equivalent figures were 1,210 hours and 877 landings. (Note: the ratio of hours to flight cycles altered during recent years as the aircraft latterly had been operated predominantly in the parachute training role). It is thus likely that the landing gear lever had actually achieved approximately 6,200 landings.

The overhaul life was stated as 10,000 landings or 9,600 hours (a major airframe inspection occurs at the latter figure), which the aircraft had not yet achieved. The ultimate life of the lever may be extended to either 27,000 or 30,000 landings (depending on the certificated aircraft all-up weight), subject to compliance with two relevant Service Bulletins, which were initially issued in 1982.

Summary

The landing gear lever failed in two stages, the initial part occurring as a result of stress corrosion. The applied stress is likely to have been due to the weight of the aircraft whilst it was parked, and the failure appeared to be the result of cracks that had developed in the surface of the internal bore of the lever, most probably as a result of inadequate paint protection. The presence of corrosion on the surfaces of the initial fracture indicated that the failure had occurred a considerable time, probably

months, prior to the accident. Following the initial failure, the stress levels across the section would have increased, although not necessarily uniformly. The final failure was not characterised by a fatigue process: the metallurgical examination indicated that failure resulted from a single overload. Although there was no evidence to suggest that the landing on which the failure occurred was exceptionally heavy, there was a possibility that one of a number of significant ruts in the runway surface could have contributed to the failure.

The lack of documented history on the landing gear levers meant that the hours, landings and repair details of the left lever could not be established. In the absence of component record cards, no explanation was forthcoming as to why the appropriate information had not been entered in the aircraft log books.

The aircraft maintenance organisation had erred on the side of caution and assumed that the landing gear levers had achieved the same hours and cycles as the airframe. However, interpolation of the available information indicated that the actual number of cycles achieved by the left lever was only around 6,200, well short of its overhaul figure of 10,000 landings. Moreover, the lever should have been capable, subject to satisfactory inspections, of achieving up to 30,000 landings.

The global Skyvan fleet, is now very small with only three aircraft, including G-PIGY, on the UK register. The landing gear manufacturer has no knowledge of any similar failure having occurred throughout the fleet's history. It was therefore concluded that the subject incident was an isolated occurrence with its origins in an incomplete paint treatment within the bore of the left landing gear lever. It could not be established whether the defective paint treatment was applied at manufacture or the subsequent repair.