Accidents Investigation Branch

Department of Transport

Report on the accident to Pilatus PC-6/B2-H2 Turbo Porter G-BIZP at Yarwell near Peterborough on 18 December 1983

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Department of Transport
Accidents Investigation Branch
Royal Aircraft Establishment
Farnborough
Hants GU14 6TD

16 January 1985

The Rt Honourable Nicholas Ridley
Secretary of State for Transport

Sir,

I have the honour to submit the report by Mr C C Allen, an Inspector of Accidents, on the circumstances of the accident to Pilatus PC–6/B2–H2 Turbo Porter G–BIZP which occurred at Yarwell near Peterborough on 18 December 1983.

I have the honour to be
Sir
Your obedient Servant

G C WILKINSON
Chief Inspector of Accidents

Contents

Accident Investigation Branch

Aircraft Accident Report No: 6/84
(EW/C858)

Operator:	Peterborough Parachute Centre Ltd
Aircraft: *Type:*	Pilatus PC–6/B2–H2 Turbo Porter
Nationality:	United Kingdom
Registration:	G–BIZP
Place of Accident:	Yarwell near Peterborough, Cambridgeshire. 52° 34′N 00° 24′W
Date and Time:	18 December 1983 at 1042 hrs
	All times in this report are GMT

Synopsis

The accident was notified to the Accidents Investigation Branch at 1156 hrs on 18 December 1983 and the investigation was commenced on the following day.

The aircraft had been attempting to make a parachuting flight, but the flight was abandoned due to cloud cover over the dropping zone (DZ). During the descent, part of each aileron separated, in sequence, from its respective wing. Under instructions from the pilot, all eight parachutists on board evacuated the aircraft and landed safely. The aircraft adopted a steep bank angle to the right which developed into an uncontrollable turn. The pilot was, however, able to moderate the rate of descent and make a partially controlled landing in a field. He received minor injuries, but the aircraft was destroyed. There was no fire.

The report concludes that the accident was caused by a loss of roll control following the failure, due to overload during the recovery from an excessively banked turn, of the rear angle brackets of both aileron control attachments previously weakened by fatigue damage. A contributory factor was the habitual use of a high speed descent technique which significantly increased the aerodynamic loads on the aircraft.

1. Factual Information

1.1 History of the flight

The aircraft, owned and operated by the Peterborough Parachute Centre (PPC), was employed almost exclusively for the purpose of dropping parachutists. It took off from Peterborough (Sibson) aerodrome at approximately 1030 hrs, with the pilot and eight parachutists on board. Although there was broken cloud cover at a height of approximately 2,000 feet above ground level (agl), it was hoped that there would be a suitable break in the cloud, sufficient for the parachutists to maintain visual contact with the dropping zone (DZ). However, at a height of approximately 11,000 feet it became apparent that the DZ would remain obscured and the decision was made to abandon the drop.

The pilot commenced a descent towards the aerodrome at an indicated airspeed (IAS) of 135 to 140 knots (kt), with the throttle selected to a torque setting of 10 psi, that is, outside the beta mode* operating range of the propeller. He then initiated a 45° banked turn to the left in order to position the aircraft for a left base turn onto runway 07 at Sibson.

At approximately 4,500 feet agl, as the aircraft was entering the tops of a layer of cloud, the pilot rolled the wings level and heard a bang; he then experienced a severe and rapid lateral oscillation of the control column. The pilot and his passengers noticed that the left aileron had partially detached and was trailing in the slipstream. The aircraft was subjected to severe vibration. Some 2 to 4 seconds later, the oscillation of the control column ceased; it was observed that the right aileron had also partially detached and was trailing from the wing. The pilot managed to correct a slight bank to the right with left rudder, and then ordered the parachutists to leave the aircraft. This they did, with alacrity, at a height of approximately 2,500 feet, whilst the aircraft was still in cloud. They fell clear of the cloud at about 2,000 feet and landed safely in nearby fields.

After the parachutists had left the aircraft in the vicinity of Wansford, 7 miles due west of Peterborough, the pilot headed south towards the aerodrome, roughly following the course of the River Nene. He reports that at this stage the aircraft began progressively banking to the right, despite the application of left rudder, until the aircraft remained banked at an angle of 45° to the right against full left rudder. Subsequently the aircraft entered an uncontrollable right turn which progressively tightened until the aircraft was heading and descending towards the village of Yarwell. At this stage, the pilot applied power to maintain a height sufficient to overfly the houses in the village; his airspeed was then in the region of 100 knots.

The pilot further described how, after the application of power, the bank angle increased to approximately 60° to the right, still against full left rudder. After clearing the houses, he therefore decided that the only course of action open to him was to continue the descent and force-land before all further control was lost. Observers saw the aircraft in a right turn, descending into a field, where the right wing and right main landing gear struck the ground and became partially detached. The aircraft then pivoted to the right through 180° and came to rest upright, but in a 30° right wing low attitude.

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* For definition see 1.6.6

The pilot evacuated the aircraft by the right-hand main door, having sustained minor injuries and fuel burns to the skin. The burns had been caused by a massive fuel leak from the left wing as a result of the impact. There was no fire.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	0	0	0
Serious	0	0	0
Minor/none	1	8	

1.3 Damage to aircraft

The ailerons, right outer wing together with the right fixed gear, and engine became detached. The fuselage and tail assembly were buckled; the aircraft was damaged beyond economic repair.

1.4 Other damage

Some fuel contamination to an unsown ploughed field.

1.5 Personnel information

Pilot:	Male, aged 25 years
Licence:	Commercial Pilot's Licence containing Groups A and B. The pilot was exercising the private privileges of his licence, which he is entitled to do under the Exemption to Article 39(2) of the Air Navigation Order.
Ratings:	Part I Pilot-in-command, Gulfstream American series AA–1 and AA–5; Piper Twin Comanche series PA30, and PA39; Pilatus Turbo Porter PC–6 B2–H2.
Medical Certificate:	Last medical examination 29 January 1982, Class 1 with no restrictions.
Certificate of Test:	29 September 1983
Total pilot hours:	2,500 hours
Total hours on type:	700 hours of which 15 were acquired during the preceding 28 days.
British Parachute Association authority to drop parachutists:	Initial authorisation was issued to the pilot on 28 April 1978. The then current authorisation issued on 29 April 1982, specified the Pilatus PC–6, Cessna 182, and Cessna 206 aircraft.

1.6 Aircraft information

A general view of the aircraft is shown at Appendix 1.

1.6.1 Leading particulars

Type:	Pilatus PC–6/B2–H2 Turbo Porter
Registration:	G–BIZP
Manufacturer:	Pilatus Flugzeugwerke AG, Switzerland
Date of Manufacture:	1981
Manufacturer's Serial No:	812
Certificate of Airworthiness (C of A):	
Category:	Private
Issued:	10 August 1981
Valid to:	9 August 1984
Registered Owner:	Peterborough Parachute Centre Ltd
Engine:	One Pratt and Whitney PT6A–27 Turboprop
Propeller:	Hartzell HC–B3TN–3D
Engine cycles:	1,303
Total airframe hours:	999.45 hours
Maintenance:	The aircraft was maintained to the Approved Maintenance Schedule No CAA/LAMS/FW/1978
Last 100 hour check:	30 August 1983 at 917.40 hours (coincident with annual check)
Last 50 hour check:	30 October 1983 at 972.20 airframe hours.

1.6.2 Aircraft weight and balance

Maximum authorised weight:	4,850 lb (2200 kg)
Estimated take-off weight:	4,842 lb (2196 kg)
Estimated accident weight:	4,770 lb (2164 kg)
Estimated weight less 8 parachutists:	3,282 lb (1489 kg)
Centre of Gravity limits @ 4,850 lbs:	18.7 ins to 25.44 ins aft of datum (AOD), or 25% to 34% of Mean Aerodynamic Cord (MAC)
Calculated Centre of Gravity at take-off:	22.9 ins AOD, 30.6% MAC

1.6.3 *Fuel*

Type:	Jet A–1 (Avtur)
Quantity at time of accident:	approximately 58 US gallons (219 litres)

1.6.4 *Flight Manual airspeed limitations*

The Flight Manual 'airspeed limits' are quoted in knots, calibrated airspeed (CAS), and correspond to the 'attention airspeeds' which are in knots IAS and marked on the face of the airspeed indicator (ASI). The relevant speeds are:

(i) Never exceed (VNE) 151 kt

(ii) Structural cruising (VC) 118 kt

(iii) Manoeuvering (VA) 106 kt

The ASI is marked with a green arc from 52 kt (flaps up speed) to 118 kt (VC). The arc from 118 kt to 151 kt (VNE) is yellow, and is known as the cautionary range. The VNE speed is marked by a red radial line.

The normal operating speed (VNO) as defined in the British Civil Airworthiness Requirements (BCAR's) is, in this case, coincident with the Flight Manual VC of 118 kt.

1.6.5 *Effect on wing loading of varying bank angle and all-up weight*

Estimated wing loading, level flight, accident weight	15.48 lb/ft^2
Estimated wing loading, level flight, accident weight less 8 parachutists	10.72 lb/ft^2
Estimated wing loading, 45° bank, accident weight	21.89 lb/ft^2

1.6.6 *Operating procedures*

The following extracts from the PC–6 Airplane Flight Manual outline the operation of propeller pitch and power controls in the Beta range. "Propeller speed is kept constant at any pre-selected propeller control position by the propeller governor, except in the beta range where the maximum propeller speed is controlled by the pneumatic section of the propeller governor.

Beta Range

Beta mode operation of the propeller is used in flight to effect fast deceleration and high rates of descent. In the beta range, the propeller blades are set at a very low positive pitch angle to provide a braking effect for steep controlled descents. When operating in the beta mode, the propeller pitch angle is controlled by power lever movement between the lift detent and the point where constant speed operation becomes effective.

NOTE: For optimum BETA MODE operation reduce airspeed to 100 mph or below."

The manufacturer's normally recommended technique for use in parachute operations is to descend at an IAS of 118 kt with beta mode selected. This technique is used by the operator of the only other aircraft of the same type on the UK register. However, because operation in the beta mode produces a considerably enhanced noise level compared with operation outside this mode, the manufacturer recommends operators in noise sensitive areas to descend at 140 kt with a torque setting of 10 psi (ie, outside the beta range).

1.6.7 Aileron installation (see Appendix 2)

The flaps and aileron control surfaces are similar in construction, the main difference being that the flaps have a slat attached to their leading edges. The outboard attachment of the flap to the wing (at mid semi-span) is shared with the inboard end of the aileron. The outboard end of each aileron is attached by means of a small triangular bracket on the wing tip fairing. An attachment at the mid span positions of the flaps and ailerons is similar in design to the shared flap aileron attachment. In each case, the control surface is attached to a mounting bracket which is secured to the wing underside by means of four bolts. The bolts are grouped in forward and rear pairs and located into anchor nuts which are riveted to the horizontal flange of an angle bracket inside the wing structure. The vertical flange of the angle bracket is riveted to the diaphragm that forms part of the structure of the wing. The manufacturer has stated that the rear angle bracket installation has been stressed to a design load of 4598 Newtons. The attachment is hidden from view by the lower surface wing skin, which has an average thickness of 0.58 mm.

Each aileron consists of two halves joined at the mid span point, in line with the central mounting bracket on the wing. The joint is effected by means of the control horn which is linked to the aileron push-pull rod emerging from the wing, and the mounting bracket. The flanks of the control horn are also riveted to the abutting end ribs of the two aileron halves. The two halves are further linked at the trailing edges by a 'Flettner tab', which is a servo tab operated, when the aileron is deflected, by means of a rod attached to the mounting bracket.

1.6.8 PC–6 fleet history

Since the first flight of a piston engined PC–6 in 1959, some 440 aircraft have been built, including licensed production by Fairchild in the USA. The majority of these aircraft were turboprop variants, and production continues at the rate of 10 per year. Pilatus estimate that the world-wide fleet has accumulated in excess of 4 million flying hours, with high time aircraft having achieved more than 15,000 flying hours each. The aircraft is operated in a wide range of roles across the spectrum of climatic conditions. The aileron support installation has remained unchanged until revised by Service Bulletin (SB) 138 issued in December 1982 (see 1.17.2).

1.7 Meteorological information

Meteorological information was obtained from an assessment made by the pilot and an aftercast compiled by the Meteorological Office, Bracknell. Weather observations are not routinely made at Peterborough Sibson aerodrome, nor are they required to be.

Pilot's observation

Surface wind:	south south-easterly 15 kt
Visibility:	more than 10 km
Temperature:	14-15°C
Cloud:	7-8 oktas at 3,000-4,000 feet

Aftercast

Wind above 2,000 feet above mean sea level (amsl):	150° true, 30-35 kt
Visibility:	8-15 km
Height of 0°C isotherm:	3,000 feet
Cloud:	1-5 oktas of stratus base 1,000-1,500 feet, tops 2,000 feet 4-7 oktas of stratocumulus layers between 3,500 feet and 6,000 feet
Warning and remarks:	moderate low level turbulence

Statements by the pilot and parachutists do not, however, indicate that any significant turbulence was encountered.

The accident occurred in daylight.

1.8 Aids to navigation

Not relevant.

1.9 Communications

The pilot was in RTF contact with the PPC on their own Air/Ground frequency of 129.9 MHz, and was able to inform them of the mishap to the ailerons. No other distress call was made.

1.10 Aerodrome and ground facilities

Peterborough (Sibson) aerodrome is operated by the Peterborough Aero Club, and has two grass runways: runway 07/25, 703 metres long and 30 metres wide; and runway 15/33, 551 metres long and 18 metres wide. The aerodrome is 100 feet amsl. There is an Air/Ground radio service, with call-sign 'Sibson Radio', on 122.3 MHz. The PPC is based at, and principally operates from, Sibson.

1.11 Flight recorders

The aircraft was not equipped with a flight data recorder or cockpit voice recorder, nor were these required to be installed.

1.12 Wreckage and impact information

1.12.1 On site examination

The activities of recovery vehicles in the area around the wreckage had completely obliterated the ground marks caused by the aircraft at impact. Accordingly, it was not possible to verify the impact parameters as described by the pilot and witnesses. Nevertheless, the detachment of the right-hand main gear, plus the damage to the outboard section of the right wing and to the nose area, was clear evidence of a significant angle of bank to the right at impact.

It became apparent that one half of each aileron was missing from the wreckage. The outboard half of the right aileron, complete with mass balance, was discovered 1.6 miles north-east of the accident site. The inboard half of the left aileron was found in a field approximately 0.5 miles north-west of the right aileron portion, 1.7 miles from the accident site.

Prior to recovery of the wreckage, the wings had been removed from the fuselage. This operation was carried out by the chief engineer of the company which maintained the aircraft, and he had verified that there had been no pre-impact disconnection to any of the flying controls running through the wing root area.

1.12.2 Subsequent detailed examination

The wreckage was removed to a hangar at Sibson aerodrome, where an examination of the flying controls revealed no evidence of a pre-impact failure or disconnect in the aileron circuit upstream of the aileron push-pull rods. The rudder, elevator and flap systems were all intact and it was evident that, at the moment of impact, the flaps had been retracted. As found, the position of the rudder trim indicated 2 units (out of 6) right rudder trim selected.

The pitot system was checked for freedom from obstruction and the airspeed indicator was subjected to a calibration check, which proved satisfactory.

Subsequently the wings and aileron fragments were removed to the AIB facility at the Royal Aircraft Establishment at Farnborough for detailed examination.

It was found that both left and right ailerons had become detached in an identical manner, the initial failure occurring at the central of the three attachments. In each case, the mounting bracket had pulled out of the wing undersurface, causing the centre portion of the aileron to be no longer restrained in the vertical plane. The resulting motion had caused each aileron push-pull rod to be 'guillotined' at the point where it passes through a span-wise stringer in the rear of the wing. The position at which the rods had been severed indicated that the ailerons had been approximately neutral at the time of the occurrence.

Following the failure of the central attachment, each half aileron would have been tenuously joined to its neighbour by the aileron control horn and the trailing edge Flettner tab. After these had failed, it was evident from examination of the inboard and outboard attachments that each aileron half had drooped downwards and rearwards. In both cases, the aileron mounting bracket had remained with the inboard half. The left aileron inboard attachment to the shared flap/aileron mounting bracket and the right aileron outboard attachment had both failed in the air, with the resultant detachment of the two half ailerons. It was clear that impact forces had caused the final failure of the attachments of the aileron sections that had remained with the aircraft.

Despite the loads to which the shared flap/aileron attachment must have been subjected, both mounting brackets had remained attached and bore no external signs of distress.

Examination of the central aileron attachments revealed that separation was caused by failure of the angle brackets within the wing into which the mounting brackets are bolted. In the case of the left wing, both forward and rear angle brackets had failed in the radius between the vertical and horizontal flanges. In the right wing, the rear angle bracket had failed in the radius whereas the forward bracket had been pulled intact from the wing, due to failure of the rivets attaching it to the diaphragm.

A metallurgical examination revealed the presence of fatigue in each of the rear angle brackets. Damage to the fracture faces precluded any assessment of crack propagation rate; however, it was established that the cracks had resulted from the coalescence of a number of origins along a line coincident with the bases of the anchor nuts located on the horizontal flange of each angle bracket. Photographs of the failed brackets are presented at Appendix 3a and 3b and it can be seen that the fractures follow the outline of the anchor nut bases along part of their length. In particular, it was noted that fatigue had extended along 20 mm and 42 mm respectively of the total length of the fractures on the left and right wing angle brackets.

The metallurgical examination revealed no defects in the material specifications of the angle brackets.

The aileron stops, which are located on the bellcrank that is attached to the forward end of the aileron operating rod, bore no signs of excessive impact that might have been indicative of high amplitude control surface oscillation. In the structurally intact left wing, the control cables that link the wing root bellcrank with the aileron operating bellcrank were still intact.

No significant wear was observed in the Flettner tab operating mechanism or hinges that might have contributed to aileron instability.

1.13 Medical and pathological information

Not relevant.

1.14 Fire

There was no fire.

1.15 Survival aspects

The pilot and the eight parachutists survived the accident. The parachutists were fully equipped, and had been ready to jump; on the advice of the pilot, they abandoned the aircraft. All were well experienced and jumped at a height well above the minimum of 500 feet agl recommended in the British Parachute Association's Parachuting Pilot's Brief. All eight landed safely.

The pilot was not wearing a parachute, nor was he required to under the provisions of Civil Aviation Authority (CAA) Supplement No 1, issue 3, to the approved Pilatus Flight Manual. He was, however, wearing upper torso restraint, which held upon impact, with the result that he suffered only minor injuries to his face and right leg.

As a result of the impact, an extensive fuel leak from the left wing allowed fuel to pour down the pilot's door and soak him in Avtur. He decided to leave the aircraft on the side away from the leaking fuel, ie through the right main door, which had been left open. The deputy chief instructor of the PPC, who had received the pilot's RTF distress call, reached the accident site shortly afterwards and accompanied the pilot back to the aircraft in order to switch off those systems and items of equipment which might have constituted a hazard.

The police and emergency services had been alerted by eye witnesses and arrived on the scene promptly. Due to impact forces, the engine had become detached from the airframe and there was no fire.

1.16 Tests and research

None.

1.17 Additional information

1.17.1 Previous similar structural problems on PC–6 aircraft

The first instance of cracks in angle brackets was observed in 1975 on the Pilatus demonstrator and flight test aircraft, at a total flight time of some 400 hours. During a pre-flight inspection, cracks were noted in the external wing skin in the area of one of the central aileron attachments. The rear angle bracket was found to have failed completely, although this had not resulted in aileron separation. An examination of the bracket was carried out by the material manufacturer who concluded that failure was caused by a fatigue crack originating from one of the countersunk rivet holes drilled to accommodate the anchor nuts.

No further action was taken by the manufacturer, as they knew that this aircraft had been subjected to overloading during demonstration or test flights and assumed that this was the cause of the initiation of the fatigue crack.

During June 1982, an incident occurred to a French registered aircraft, F–GDCT, that had achieved 5,583 flight hours. The pilot reported that after a party of parachutists had jumped from the aircraft at a height of 9,000 ft agl, the aircraft was put into a descent at an airspeed of 145 kt, a glide angle of 30° and with the propeller selected in the beta range. At approximately 6,500 ft agl, there was a bang originating on the left hand side and the control column vibrated approximately 10 times before becoming jammed. The aircraft became inverted and started to spin. The pilot feathered the propeller and recovered from the spin at 100 kts but with the aircraft banked at 50°. After lowering the flaps he was able to raise the wing by application of left rudder and achieve a landing on the edge of the airfield. Examination revealed that the angle brackets of the left aileron central attachment had failed, causing separation of the aileron. The right aileron was intact but distorted.

Subsequent examination revealed the presence of fatigue in the angle brackets.

1.17.2 *Service Bulletin (SB) 138*

Following the incident with F–GDCT, the manufacturer changed the design of the flap/aileron attachments with the introduction of SB 138 in December 1982. Similar design philosophy was embodied for each of the three flap/aileron attachments per wing. The installation for the central aileron attachment is illustrated at Appendix 4.

Essentially, the Bulletin replaced the angle bracket with an alloy fitting, which was attached to the diaphragm within the wing and into which the flap/aileron mounting bracket bolts were directly located.

Compliance with the Bulletin, which was approved as an Airworthiness Directive (AD) by the Federal Office for Civil Aviation of Switzerland, was as follows:–

> Aircraft up to 1,000 flight hours. Compliance required within the next three periodic inspections.
>
> Aircraft up to 2,000 flight hours. Compliance required within the next two periodic inspections.
>
> Aircraft with more than 2,000 flight hours. Compliance required at or before the next periodic inspection.
>
> Aircraft which have been subjected to an overspeed condition. Compliance required as soon as possible.

Note Periodic inspections are every 100 flying hours.

The reason for the introduction of the Bulletin was stated as being due to the discovery, in two instances, of cracks in the angle brackets forming the attachments of the aileron/flap mountings. The Bulletin further commented that:

> "The cracks are probably attributable to fatigue caused by the aircraft being subjected to overspeeding. In one instance, the attachment failed completely, resulting in the loss of an aileron. Subsequently, several high-time aircraft have been inspected, and the attachments have been found to be completely serviceable. However, due to the impracticability of carrying out regular in-service inspections of the affected parts, it has been decided that the attachment must be replaced."

The Bulletin is applicable to all PC–6 Porter and Turbo-Porter models up to and including aircraft manufacturer's Serial No 815. On subsequent airframes, the Bulletin modification is incorporated during build.

Because the Bulletin had been adopted as an AD by the Swiss Authority, compliance with it became mandatory in the UK under the terms of Airworthiness Notice No 36. This status was confirmed by the CAA's March 1983 issue of Foreign Airworthiness Directives which promulgated Swiss AD No 83-018.

At the time the Bulletin was issued, the manufacturer still assumed that the company demonstrator aircraft had been overloaded and that low time aircraft were not at risk. The variable compliance times were selected as a result. In addition, it was thought that angle bracket failure did not necessarily result in aileron detachment, as the incident with the company aircraft indicated that a certain amount of load carrying capability still existed in the wing skin.

Following the accident to G–BIZP, the manufacturer revised SB 138 such that all aircraft operating, or that had been operated, in the parachuting role, should be modified before the next flight. For all other aircraft, the variable compliance times remained as before.

1.17.3 *Experience since the introduction of SB 138*

By the end of January 1984, the manufacturer had incorporated SB 138 on eleven aircraft in their own workshops. Of this number, five aircraft had been used at some time for parachute operations, and three of these exhibited cracks in the aileron support angle brackets. These aircraft had achieved 6,093, 1,784 and 2,732 flying hours respectively. No cracks were found in those aircraft that had not been used for parachuting although, in some cases, visible notches had been made by the anchor nut flanges in the angle bracket material. These aircraft had achieved, on average, 4,500 flying hours.

The only other PC–6 on the UK register, G–AOPA, which was operated by the Army Parachute Association, was modified in August 1983 at 485 flying hours. No cracks were observed in the angle brackets.

The manufacturer stated that by the middle of January 1984, 108 Service Bulletin kits had been delivered.

1.17.4 *Embodiment of SB 138 on G–BIZP*

On March 1st 1983, the PPC wrote to the manufacturer asking if the maximum time limit before compliance with SB 138 could be extended from 300 to 400 hours. The letter pointed out that G–BIZP had achieved "less than 500 flying hours", and that carrying out the work within the 300 hour limitation would involve the aircraft being grounded at the peak of the parachuting season, with a consequent loss of revenue. A further letter, dated May 4th 1983, requested an extension to 500 hours. Due to the fact that the Service Bulletin had been given the status of an AD by the CAA, these requests should, properly, have been addressed to the authority, although the latter would have sought the views of the manufacturer in deciding whether to grant an extension. As it was, the manufacturer did grant the PPC an extension to 500 hours in view of the fact that the incident to the French aircraft was the only one known to the manufacturer at that time and that G–BIZP would have achieved less than 1,000 hours even with the extension.

On February 1st 1983, SB 138 had been re-issued in a revised form, pointing out that the compliance times were dependent on the flying hours achieved by the wings, as opposed to total aircraft hours. A letter from the manufacturer to the PPC dated March 1st 1983 (ie before the extension had been granted) indicated that compliance with SB 138 for aircraft with fewer than 1,000 flying (wing) hours should be within 300 hours of the date of issue of the *revised* bulletin. It is apparent from the log book of G–BIZP that, at the time of issue of the revised Bulletin (February 1st 1983), the aircraft had achieved 526 hours, and not the "fewer than 500 hours" of the letter dated a month later. In fact the 500 hour mark had been passed in November 1982.

It was planned that SB 138, which requires the expenditure of 95 man hours, would be incorporated on G–BIZP during the Christmas 1983 holidays, and work was due to commence on the day following that upon which the accident occurred.

1.18 New investigation techniques

None.

2. Analysis

2.1 General

The circumstances of the accident are well established. The aircraft was descending at a speed which the pilot recalls as 135-140 kt, with a full complement of parachutists aboard, after the weather over the dropping zone had been judged as unsuitable for parachuting. Whilst the aircraft was being rolled to the wings level attitude from a left hand spiral dive, and at an altitude estimated by the pilot to be approximately 4,000 ft, both ailerons became detached at their central attachment to the wings, resulting in the loss of one half of each aileron and leaving the other half ailerons trailing from their single remaining attachments. From eye witness accounts it is clear that the left aileron was the first to fail, although engineering evidence on its own was insufficient to confirm this.

A curious aspect of the failure is that following the detachment of part of each aileron, it was the outboard half of the left aileron and the inboard half of the right aileron which remained with the aircraft. The increased lever arm of the left aileron drag component might be expected to have encouraged the aircraft to enter a turn to the left, although in fact the aircraft tended to turn to the right. It must be concluded that, in the aircraft's damaged state, the two aileron halves were contributing widely differing lift/drag forces to the aircraft.

2.2 The failure of the aileron attachments

The presence of fatigue in the rear angle brackets of both aileron central attachments had clearly weakened the brackets to the point of failure under the action of flight loads experienced during the descent. At the moment of failure, the aircraft was rolling out of a 45° banked turn, with the up-going (left) wing consequently developing more lift than the down-going wing. For an aircraft banked at 45°, the wing loading is increased by 41% over the straight and level condition. Furthermore, the effect of the weight of the eight parachutists was to increase the average wing loading by more than 44%. The total result, in the case of G–BIZP, was that the wing would have been developing in excess of 2,000 lb additional lift, when in a 45° turn, compared with a total aircraft weight of only some 3,300 lb with the pilot alone on board.

During the time when the aircraft was being rolled level, the left wing would have been developing still more lift by virtue of the down-going left aileron. Clearly, the ailerons would have borne a portion of the increased wing loading, with the left aileron carrying more load than the right. For this reason, it is not surprising that the left aileron attachment failed first, despite the fact that the angle bracket from the right aileron had a fatigue crack twice the length of that of the left bracket. Nevertheless, it is concluded that the right aileron attachment was in a condition of imminent failure, and this might well have occurred at a relatively low bank angle had the aircraft been descending in a right hand turn. Following the failure of the left aileron attachment, it is probable that the consequent loss of restraint in the vertical plane caused a fluttering action, which, prior to 'guillotining' the push-pull rod, fed an oscillatory load into the aileron operating circuit, thereby causing failure of the fatigue weakened right aileron angle bracket.

2.3 Factors affecting fatigue crack initiation

Information supplied by the manufacturer has shown that, apart from the company demonstrator aircraft, the incidence of cracked angle brackets has so far been restricted to those aircraft which have been operated in the parachuting role. Whilst there appears to be no correlation between crack incidence and aircraft operating hours, there is evidence to suggest that a relevant factor is the manner in which the descent is made once the parachutists have departed from the aircraft. For example, the only other PC–6 on the UK register at the time of the accident habitually carried out low speed descents with the propeller in the beta range. However, for environmental reasons, the descents in G–BIZP were always made at relatively high airspeeds, with the propeller in the normal pitch range. The fact that no cracks were found on the PC–6 which used the low speed descent technique suggests a probable correlation between crack initiation and elevated aileron loads due to manoeuvring during high airspeed descents. In any event it would be reasonable to assume such a link, since it is structural considerations which are responsible for the imposition of airspeed limitations on most types of aircraft.

Apart from the airspeed relationship with crack occurrence, it is also possible that other, unquantifiable, variables are responsible for the otherwise random nature of these occurrences. These could be, for example:

small differences in angle bracket material thickness or quality

fine positioning of the anchor nuts in the angle of the bracket

type of edge (ie sharp or radiussed) on anchor nut bases

differences in aileron deflection rates.

2.4 Service Bulletin 138

The potential weakness of the aileron attachments was demonstrated by the incident in June 1982 to a French registered aircraft which had achieved 5,583 hours. Thus, at the time that SB 138 was issued in December 1982, the manufacturer considered that low time aircraft were not at risk. This is reflected in the varying times for compliance with the Bulletin, which appear to have been selected with a view to minimising the inconvenience to operators rather than from an assessment of crack propagation rates or critical crack length. It was not until after the accident to G–BIZP that a survey of factory modified aircraft identified a probable link with aircraft that had been operated in the parachuting role.

Notwithstanding this, the fact remains that G–BIZP would not have suffered the subject accident had SB 138 been embodied within the stated timescale, ie within 300 hours from the date of issue of the Bulletin. Faced with their aircraft being grounded at the peak of the parachuting season, the PPC requested an extension from the manufacturer. It is apparent from the correspondence that the manufacturer was given the impression that the total hours achieved by G–BIZP were slightly less than those actually achieved, although there is nothing to suggest their response would have been any different had they known the true operating hours. The manufacturer noted that, even with the extension that they had granted, SB 138 would still be incorporated before the aircraft had achieved 1,000 hours. Indeed, G–BIZP had been scheduled for modification immediately after the flight on which the accident occurred, at which time 999.45 flying hours had been achieved.

The manufacturer's attitude towards the PPC's request was probably coloured by their experience in 1975 with the company demonstrator aircraft; in that case cracks had appeared in the skin around the central aileron attachment following the complete failure of an angle bracket. This had convinced them, firstly, that an angle bracket failure was not necessarily catastrophic, since some load bearing ability was displayed by the skin and, secondly, that failure of the angle bracket would be indicated by cracks in the wing skin, and that these would be visible on a pre-flight inspection. However, it does not seem reasonable that the wing skin, with a thickness of some 0.58 mm, would make a significant long-term contribution to the strength of the installation, even allowing for the fact that normal flight loads would impose only a fraction of the design load of the attachment. Furthermore, it is likely that with 'running changes'*, which are often a feature of parachuting operations, several 'flights' would elapse between pre-flight inspections.

It is noted that, in the revision to SB 138 following the accident to G–BIZP, all aircraft that were operated, or had been operating, in the parachuting role were required to be modified before the next flight. This is a sensible revision to the Bulletin, although for all aircraft operated in other than the parachuting role, the variable compliance times remain. However, there would seem little justification in retaining these, in view of the random nature of crack occurrences. Indeed, their very randomness (with respect to aircraft operating hours), coupled with the low number of aircraft surveyed by the manufacturer, does not provide a high degree of confidence in the statistical evidence that the problem is entirely confined to those aircraft operated in the parachuting role. In view of the difficulty, if not impossibility, of inspecting the aileron attachments and the potentially catastrophic consequences of such a failure, it would seem a wise precaution to revise further SB 138 to achieve the modification of all aircraft, regardless of their operating role, as soon as practicable.

2.5 Operational aspects

The pilots of the PPC were understandably constrained by noise abatement considerations from carrying out their descents using the beta mode to give additional braking effect, and instead descended at speeds which were relatively high for the aircraft type. Although this technique may well have contributed to the progressive weakening of the aileron central attachments there was nothing to prevent its use – indeed the technique was recommended as an alternative by the manufacturer – providing always that the pilots concerned kept within the constraints inherent in operating above the normal operating speed (VNO). That is to say, there should be little or no turbulence present, and only gentle manoeuvres should be undertaken.

An experienced pilot, such as the pilot of G–BIZP at the time of the accident, should have appreciated that descending in a 45° banked turn whilst flying at 15-20 knots above VNO could by no means be deemed to fall within this category, involving as it must a substantial increment of positive 'g'. An additional reason for caution whilst flying above VNO, which the pilot might reasonably be expected to have taken into account, was the extra weight of the eight parachutists who would not normally have been on board during routine descents to the aerodrome. However, it must be borne in mind that the state of the right aileron angle bracket was such that it would almost certainly have failed within a very short period regardless of the type of manoeuvre made.

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* embarking successive loads of parachutists without shutting down the engine.

3. Conclusions

(a) *Findings*

(i) The pilot was properly licensed and sufficiently experienced for the flight.

(ii) The aircraft had a valid Certificate of Airworthiness and had been maintained in accordance with an approved maintenance schedule.

(iii) The aircraft's weight and centre of gravity were within the prescribed limits.

(iv) Control of the aircraft in the rolling plane was lost following failure of the rear angle brackets of each aileron central attachment and the subsequent detachment of part of each aileron.

(v) The rear angle brackets had become weakened as a result of fatigue to the point where failure occurred under elevated flight loads.

(vi) The elevated flight loads occurred during the recovery from a turn at an angle of bank that was excessive bearing in mind the high speed and weight of the aircraft at the time.

(vii) It was not possible to establish with certainty the cause of the fatigue in the aileron angle brackets; however, it is probable that the crack initiation was a consequence of increased aileron loads whilst manoeuvring during the comparatively high speed descents which were a routine feature of this aircraft's operations and which had been approved by the manufacturer.

(viii) Although a potential weakness of the aileron attachments had already been recognised by the manufacturer, previous failure experience was limited such that the manufacturer had been unable to identify the type of aircraft operation that presented the highest failure risk.

(b) *Cause*

The accident was caused by a loss of roll control following the failure, due to overload during the recovery from an excessively banked turn, of the rear angle brackets of both aileron control attachments previously weakened by fatigue damage. A contributory factor was the habitual use of a high speed descent technique which significantly increased the aerodynamic loads on the aircraft.

4. Safety Recommendations

4.1 It is recommended to the Swiss certification authority that consideration be given to the implementation of Service Bulletin 138 to all PC–6 aircraft as soon as practicable.

C C ALLEN
Inspector of Accidents

Accidents Investigation Branch
Department of Transport

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