DHC-8-311, G-BRYP

AAIB Bulletin No: 6/99 Ref: EW/C99/2/5 Category: 1.1

Aircraft Type and Registration:	DHC-8-311, G-BRYP
No & Type of Engines:	2 Pratt & Whitney PW-123 turboprop engines
Year of Manufacture:	1992
Date & Time (UTC):	28 February 1999 at 1118 hrs
Location:	Plymouth City Airport
Type of Flight:	Public Transport
Persons on Board:	Crew - 4 - Passengers - 9
Injuries:	Crew - None - Passengers - None
Nature of Damage:	Extensive damage to left-hand propeller blades and aft fuselage structure. Further damage to nose landing gear, left-hand main landing gear and landing gear doors
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	44 years
Commander's Flying Experience:	11,750 hours (of which 4,800 hours were on type)
	Last 90 days - 163 hours
	Last 28 days - 55 hours
Information Source:	AAIB Field Investigation

History of flight

The flight crew reported for duty at 0930 hrs at Bristol Airport to prepare for a four sector flying day. The commander had checked the weather forecast and, since it was expected to deteriorate throughout the day, the crew agreed that the first officer would be the handling pilot for the first two sectors. The first officer was the holder of a Commercial Pilot's licence with a total flying experience of 1,040 hours of which 750 hours were on the DHC-8. Prior to departure for the first sector to Plymouth, the latest weather actual report at destination was timed at 0850 hrs and showed a surface wind of 230°/12 kt, a visibility of 6,000 metres, cloud few at 1,000 feet agl and a temperature of 9°C. There were no significant unserviceabilities noted in the Technical Log.

Take off from Bristol was recorded as 1045 hrs and, throughout the subsequent flight, both crew members considered that G-BRYP was fully serviceable and that no icing conditions were

experienced. During the transit, at 1053 hrs, the commander called Plymouth ATC on his secondary radio to inform them of the aircraft's expected arrival time and to ask for the weather conditions. Amongst other information, the controller advised G-BRYP that Runway 31 was in use and that the surface wind was 240°/16 kt maximum 22 kt but had been gusting up to 26 kt within the previous 10 minutes. The commander acknowledged this message and noted the weather on his flight log. He also asked the first officer: "You're OK for crosswind landings at Plymouth are you?"; the first officer replied in the affirmative. Then, at 1107 hrs the crew were transferred to Plymouth ATC and were subsequently cleared via 'ERMIN' for an ILS to Runway 31; both crew members were familiar with the approach procedures into Plymouth City Airport. During the descent, the commander noted from the Flight Management System (FMS) display that the wind was indicating approximately 30 kt around 1,500 feet to 1,000 feet agl. He commented to the first officer that it would probably be "quite bumpy on approach" and that he should advise the commander if he was unhappy; the first officer replied that he would. Around this time, another aircraft called for start clearance on the radio frequency and was advised that the wind was 240°/17 maximum 23 kt and with a gust in the previous 10 minutes of 27 kt. By 1115 hrs the first officer had established G-BRYP on the ILS and the crew were asked by ATC to report at three miles DME range. Just after the selection of Flap 15, the commander again asked the first officer to tell him if he was not happy at any stage; the first officer acknowledged. When the commander called at three miles DME, the controller cleared them to land with a surface wind of 230°/16 gusting 26 kt. The commander acknowledged this clearance and then told the first officer that he might have to take control. Thereafter, the commander continued to closely monitor the approach and offer advice to the first officer. He suggested hand flying the aircraft to get a better feel for the wind conditions and made particular mention of the possible need to increase engine power in the event of a sudden loss of airspeed. As the aircraft crossed the threshold, the controller passed an instantaneous wind reading of 240°/ 22 kt to the crew.

The landing weight of G-BRYP was 34,000 lb and the crew had calculated a Vref of 98 kt based on a final setting of Flap 15. The runway and Precision Approach Path Indicators (PAPIs) were visual from approximately 5 nm range and 'Two reds and two whites' were maintained during the approach. In accordance with normal company operations, the first officer used the 'Crab' technique initially and then changed gradually to the 'Wing down' technique for the landing. The aircraft was fully configured for landing by 1,000 feet agl. The first officer considered that he maintained 130 kt in the early part of the approach and had reduced his airspeed to Vref plus 10 kt by the runway threshold. The conditions were 'Blustery' on approach but aircraft control appeared normal up to the point that the first officer 'Flared' the aircraft. Then, G-BRYP suddenly lost height and the left gear contacted the runway. Subsequent contact with the ground was with the right gear and then the nose gear. Thereafter, the aircraft appeared to be level but then started slowly tilting to the left. By now, the commander had taken control and was using the control wheel to try and counteract the left bank. He was unsuccessful and the aircraft came to rest, left wing low, on the runway after a ground roll of approximately 340 metres. The commander made the decision to evacuate and informed the first officer who then transmitted a request to ATC for the emergency services. Both crew members completed their emergency procedures before leaving the cockpit.

The ATC controller had watched the aircraft land on Runway 31, adjacent to the PAPIs. He described the landing as "heavy" and shortly after touchdown, he saw the left gear fold backwards. As the aircraft slid along the runway, the controller alerted the fire services; his assistant simultaneously alerted the local emergency services.

Within the aircraft after touchdown, the number two cabin attendant seated at the rear noticed a smell and some acrid smoke within the cabin. Therefore, both attendants initiated an emergency

evacuation once the aircraft came to rest and the propellers had stopped. The senior attendant opened the front left door and the number two attendant ushered the passengers forward and out of the door and then away from the aircraft. Once all the passengers were clear, the senior attendant left the aircraft followed by the flight crew.

The AFS arrived at G-BRYP just after all the occupants had evacuated. A foam blanket was applied and maintained to the left and underside of the aircraft. Additionally, following information that smoke had been seen inside the aircraft, the Senior Fire Officer sent a Breathing Apparatus (BA) Team inside the cabin; the cabin was declared safe without any fire appliances being used.

Recorded information

The recording of audio from the CVR fitted to the aircraft was of excellent quality and covered the last 30 minutes of the accident flight. The FDR, which was a Sundstrand F800, retained 25 hours of aircraft data and included the whole of the accident flight. All the relevant accident flight data was recovered with the exception of a period of four seconds commencing at the point of touchdown.

The recordings show that the first officer was the handling pilot with the commander operating the radios. The CVR indicates that the crew were operating well together. An ILS approach was flown with autopilot engaged, and the localiser was intercepted at 2,200 feet agl. The glideslope was captured half a minute later and the aircraft began to descend on the profile. By 1,650 feet agl, the gear was lowered and landing flap of 15° was selected.

At the commander's suggestion, the autopilot was disconnected at 1,000 feet agl and the remainder of the flight was flown manually. During the approach, the variations observed in the recorded values of normal acceleration (0.58g to 1.35g) indicate moderate turbulence. Down to 440 feet agl the aircraft was flown using the 'Crab' technique with the aircraft heading 291°M but tracking along, or slightly to the left of, the localiser centreline. Indicated airspeed remained relatively constant during this phase, centred around 127 kt.

From 440 feet agl, progressively increasing right rudder and left wing down aileron were used to bring the heading of the aircraft right onto 307°M whilst still tracking along the extended centreline. This technique resulted in an average roll attitude of 4.5° left wing down with a maximum variation between wings level and 7° left wing down. Engine power was reduced and the airspeed bled off towards 110 kt; the aircraft also descended below the glidepath and two low-level 'Glideslope' audio warnings were activated at 200 feet agl. The nose of the aircraft was raised and torque on both engines increased to temporarily regain the correct profile.

During the last five seconds of flight, from 80 feet agl, airspeed values of between 109.5 kt and 98 kt were recorded and the aircraft rolled from 7° left wing down to wings level and back to 6.2° left wing down. Engine power was reduced at 34 feet agl and slight up elevator was applied. However, from 27 feet agl down to 16 feet agl, normal acceleration showed a significant drop for one second with a lowest value of 0.62g being recorded together with a reduction in aircraft pitch. No significant change in airspeed was recorded during this period but the reduction in normal acceleration indicated a sudden increase in rate of descent. Just prior to the aircraft contacting the runway heavily, over 16° of up elevator was applied. There was no indication of engine power increase at this time.

The impact resulted in the corruption of the recorded data for four seconds and therefore normal acceleration at touchdown was not available. A typical rate of descent during the latter stage of the

approach was of the order of 500 feet per minute. However, it was calculated that the average rate of descent over the last half second of flight was approximately 1,800 feet per minute. The last recorded values of pitch, roll and airspeed were 3.4° nose up, 6.2° left wing down and 103 kt respectively.

Four seconds after the touchdown, once FDR data synchronisation had been regained, it was determined that the aircraft roll angle was increasing slowly through 8° left wing down with a constant nose up pitch attitude of 3.3°. The left propeller speed had dropped to 700 RPM and the sounds of propeller strikes on the runway were audible on the CVR recording. Maximum '1roll right' aileron was used before the aircraft came to rest, 10° left wing down on a heading of 299°M, 15.5 seconds after the touchdown.

Both engines were shut down and then power was removed from the flight recorders. The left propeller was still rotating slowly (and striking the runway surface) as power was removed.

Engineering investigation

The aircraft had come to rest close to the runway centreline, with the left main landing gear folded rearwards and with extensive damage to all four of the No 1 engine propeller blades. The lower portion of the aft fuselage was resting on the runway and was extensively damaged from abrasion with the surface. The aircraft was also resting on the left wing tip and on the left main wheels and landing gear leg, which had folded against the closed landing gear doors on the underside of the left engine nacelle.

Following the accident, the source of the acrid smoke in the fuselage was investigated. The smoke was traced to portions of the aircraft insulation in the area of fuselage skin in scraping contact with the ground, where the skin had been heated by the friction with the runway. The insulating material appeared to have self-extinguished once the aircraft came to rest and the external source of heating disappeared.

In the design of the DHC-8 (Dash 8) landing gear, there is a 'fuse' pin incorporated into the hinge joint between the upper end of the oleo leg and the yoke which carries the oleo leg loads into the wing structure. This pin is designed so that loads imposed by a very heavy landing will result in the controlled folding of the landing gear leg, rather than structural damage to the wing and its integral fuel tank. It was clear that, in this case, the leg had folded due to the shearing of the fuse pin on both sides of the yoke.

One of the portions of the failed fuse pin had been found along the runway and the other two portions were subsequently removed from the leg and yoke. The fracture surfaces were later subjected to two separate metallurgical examinations. Because of the tight tolerance between the oleo and yoke, all four surfaces had suffered later mechanical damage to their fracture surfaces and the fractures were, as designed, through the machined grooves in the pin. One metallurgist noted minor features consistent with low cycle fatigue but there were no fatigue striations visible and the fractures appeared to be due to mechanical overload. The manufacturer notes that there have been no known cases of cracking in these landing gear fuse pins and the vertical velocity at touchdown, derived from the FDR, greatly exceeded the calculated vertical velocity (approximately 900 ft/min) at which the pin would be expected to fail. There was also denting damage noted to the outer rim of the left outboard wheel, the first wheel to make contact with the ground. This rim damage indicated that, in the initial touchdown, the tyre on this wheel had been distorted to the point where there was

no further pneumatic cushioning from the tyre. At this point a high instantaneous compressive load would have been transmitted through the leg, leading to failure of the fuse pin.

It was not possible to identify the wheel marks from YP's initial touchdown but the first marking from the aft fuselage scrape was in line with the PAPI boxes and continued for some 340 metres up Runway 31, to the point where the aircraft had come to rest. Marks to the left of the centreline showed that the propeller blades had made repetitive contact with the runway surface, destroying the outer portions of the blades. These propeller blades are composite construction and the roots of all four blades had been successfully retained at the propeller hub.

Following the accident, a calibration of YP's airspeed system against an external pitot-static test set was performed. This showed that both the commander's and first officer's airspeed indicators (ASIs) were within normal calibration limits.

Operational information

On all but one occasion, the surface wind information passed by the controller to the flight crew was the two minute mean wind information derived from the anemometer on top of the Glideslope aerial located to the north of the runway abeam the Runway 31 PAPIs. The other occasion was when the controller passed the instantaneous wind to the crew as the aircraft approached the threshold.

The controller had received no reports of windshear during the morning of 28 February 1999. However, within the United Kingdom Integrated Aeronautical Information Package (UK AIP), the following warning was included for Plymouth City Airport: 'In strong wind conditions windshear and turbulence may be experienced on the approach to or climb out from any runway. Downdraught effect and sudden changes in wind velocity are possible in light wind conditions.'

The ILS had been flight checked on 1 February and ground serviced on 22 February 1999; the system was fully serviceable. The PAPI system is checked for accuracy and given a routine servicing every week; it was checked as serviceable on 22 February 1999 and confirmed as serviceable on the day following the accident.

The declared Landing Distance Available (LDA) for Runway 31 is 1055 metres and the ILS and PAPIs are each set at a glide slope angle of 3.5°.

The DHC-8 flight manual details a maximum crosswind component for landing of 36 kt; this is based on a hard, dry runway and measured at a height of 10 metres. It also includes the following information on crosswind landings based on the steady state wing down/ zero crab technique: 'Approach and touchdown with upwind wing lowered, using rudder to align airplane with runway. Following touchdown hold nosewheel on runway with elevators and use ailerons to inhibit any upwind wing lifting.'

Post accident calculations confirmed that the aircraft was within normal C of G and weight limitations and that the crew had calculated the correct Vref of 98 kt.

The Company Flying Manual Standard Operating Procedures included instructions on when first officers could act as handling pilot on runways with less than 1,250 metres LDA. One instruction dated 12 October 1998 detailed a maximum wind limit of 15 kt including gusts, and a crosswind limit of 10 kt. These restrictions were amended in recent Flight Crew Notices issued on 15

February and 25 February 1999. The maximum wind limits remained at 15 kt including gusts but the crosswind limits were relaxed to 20 kt less than the captain's; the captain's crosswind limit for landing on dry runways using Flap 15 was detailed in the Company Flying manual as 35 kt. If the weather conditions were beyond the first officer's limits, the captain was to take control by 1,000 feet agl. Subsequent to the accident, both flight crew members acknowledged that they had read the Flight Crew Notices issued on 15 February and 25 February. However, the first officer considered that the inclusion of the phrase "Captains may use their discretion in setting higher for F/Os if they consider conditions merit it." to be misleading in relation to the limits.

The Company Operations Manual also details the following instructions regarding evacuations: 'In the event of a catastrophic incident where the flight deck may not have survived or be able to communicate, the No 1 must use initiative and consider the correct action. However, where no immediate danger exists in the cabin, cabin crew should wait approximately 15 seconds (whilst the pilots complete shutdown checks) for instructions via the PA.'

Accident discussion

The aircraft was serviceable throughout the flight and there is no evidence that a pre-existing failure within the fuse pin caused the left gear to collapse. Evidence from the FDR indicates that the rate of descent at touchdown was in excess of that required for the fuse pin to break. Additionally, the variation in recorded normal 'G' indicates that the aircraft was subjected to windshear as the handling pilot flared prior to touchdown. The timing of the windshear was such that prompt and correct action would be required to recover the situation; a more experienced pilot should have been able to cope with the conditions. Company restrictions had been initiated because of the experience levels of the first officers and the difficulties of landing at airfields such as Plymouth.

The CVR indicates that the crew were operating the flight in a professional manner and that they were aware of the surface wind conditions. Both pilots were aware of the Flight Crew Notices and, although the first officer subsequently stated that the wording of the Notice 4/99 was misleading, he considered that he was observing the company limitations at the time. Neither pilot discussed the company restriction but the commander asked the first officer if he was happy with crosswind landings and made other comments indicating that he might have to take control during the approach. An inexperienced first officer may not have appreciated the significance of the wind reports and would probably have been concentrating on flying an accurate approach while relying on the commander to make the final decision. Following the accident the company reissued the Flight Crew Notice with the intention of eliminating any ambiguity.

The commander was concerned about the approach but seemed reluctant to take control unless the first officer asked him to. He would be aware of the experience of the first officer and of the company restrictions. By not making a positive decision when he first realised the actual wind conditions and taking control of the aircraft, the commander allowed the situation to develop into one where the first officer landed G-BRYP in conditions outside his experience or authorisation.

Following the accident, the cabin attendants commenced an evacuation without the normal executive order from the commander. With evidence of smoke and an acrid smell within the cabin, this was a prudent decision; the evacuation was completed quickly and without incident.

The reactions of ATC and AFS personnel were prompt and effective.