

Shorts SD3-30 Variant 100, G-ZAPC

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Aircraft Type and Registration:	Shorts SD3-30 Variant 100, G-ZAPC
No & Type of Engines:	2 Pratt & Whitney PT6A-45R turboprop engines
Year of Manufacture:	1978
Date & Time (UTC):	3 January 1997 at 0042 hrs
Location:	Liverpool Airport
Type of Flight:	Cargo
Persons on Board:	Crew - 2 - Passengers - 1
Injuries:	Crew - None - Passengers - None
Nature of Damage:	Right main gear collapsed
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	39 years
Commander's Flying Experience:	3,015 hours (of which 900 were on type) Last 90 days - 149 hours Last 28 days - 51 hours
Information Source:	AAIB Field Investigation

History of flight

The amended UK Low Level Forecast for the period 1800 hrs to 2400 hrs issued by the Meteorological Office at 1515 hrs showed cold anticyclonic airflow with winds from the east. A weak cold front on the surface would extend across the Midlands on either side of which the freezing level would be at or below 1,000 feet amsl and the visibility would be generally 15 km. South of the front there would be 2/8 to 6/8 cumulus or strato-cumulus cloud between 1,500 and 5,000 feet. North of the front there would be 6/8 cumulus or strato-cumulus cloud between 2,000 and 7,000 feet. Moderate icing and turbulence in cloud was forecast on both sides of the front and ahead of it (to the north) there would be low cloud and poor visibility due to snow or freezing fog.

The aircraft and crew were based at Exeter where their normal work pattern was the servicing of a night cargo-delivery contract. The crew reported for duty at 2000 hrs for the first scheduled leg which was to Plymouth to collect cargo. However, after starting engines a technical defect occurred

within the left aircraft's hydraulic system and the flight was cancelled. The defect was rectified in time for the main scheduled sector of the night which was from Exeter to East Midlands.

The aircraft departed Exeter at 2237 hrs where the weather was fair with scattered cloud at 1500 feet. After climbing uneventfully through cloud to FL 90 the aircraft cruised in clear, smooth air. In the cruise the co-pilot noticed that this vertical speed indicator was displaying a slight rate of climb although the aircraft was in level flight but this and a spurious hydraulic warning were the only anomalies. As the aircraft approached East Midlands airport the runway visual range there was below the approach minima and several aircraft were holding awaiting an improvement in the visibility. G-ZAPC descended to 2,500 ft and held in clear air over the Lichfield NDB for about 45 minutes until the fuel state dictated a diversion to Liverpool. On diversion the aircraft was initially cleared direct to the Whitegate NDB and then Wallasey VOR at FL 40. At this level the crew could see ground features in good visibility until they entered cloud as they descended through 3,500 feet whilst being radar vectored for an approach to Liverpool Airport. The cloud was stratiform in character and did not appear to contain precipitation or significant turbulence. At Liverpool airport the cloud base was 6/8 at 1,100 feet, the visibility 12 km, the air temperature +1°C and the surface wind was 060°/8 kt.

There is an ILS localiser on Runway 09 but no glidepath transmitter so a LOC DME approach is normally flown. Although the DME antenna is mid-way along the runway, the DME range is set to read zero at the runway displaced threshold. The pilot flies the localiser in azimuth and adjusts his height according to his pressure altimeter; the 3° glidepath commences at 1,610 feet QNH from 5 nm DME with check heights at 4, 3, 2 and 1 nm DME. On the north side of the runway 329 metres from the threshold there are 4 PAPI (Precision Approach Path Indicator) lights which are set to a glidepath of 3°.

During the approach to Runway 09 at Liverpool all the anti-icing services were switched on and operating except for the wing de-icing boots which, having seen no ice on the wings, the commander decided not to employ, and the ice detector which he considered unreliable. The approach proceeded normally and the aircraft descended out of cloud at about 1,100 feet having been in cloud for about 10 minutes.

When the commander viewed the PAPIs at 1 DME "all four lights had a pink tinge". Thinking he might be slightly low relative to the approach glidepath, he asked the co-pilot to specify the correct height at 1 DME which was 410 feet. At the time the commander's pressure altimeter, which was set to the QNH of 1019 mb, indicated that the aircraft was slightly high and so he made a small correction to the flight path which resulted in three red PAPI lights and one white light. The commander also decided to touch down slightly beyond the runway identifier numbers which are a few metres beyond the 'piano keys' that identify the threshold.

The aircraft was cleared to land with a wind of "Easterly at 10 kt" and on short finals the commander asked for full flap. He then allowed the speed to bleed back from the approach speed of between 110 and 120 KIAS towards the threshold speed of 90 KIAS without moving the throttles from their approach power setting. According to both crew members and the passenger who was seated in the 'jump seat', the aircraft crossed over the end of runway at between 88 and 90 KIAS. Some 20 to 30 feet above the runway the commander noticed that the flight controls felt 'sloppy' as if the aircraft's speed was unusually low but there was no hint of a stall warning or stick shaker activation. At much the same time all three persons on board felt the aircraft sink rapidly; the commander pulled back on the control column but he was unable to arrest the high rate of descent and the aircraft struck the runway very hard. The right wing dropped as the right main gear collapsed

and the aircraft veered to the right off the runway onto the grass. The ground was frozen hard and the aircraft came to a halt without incurring further significant damage. The crew informed ATC that they were unhurt before securing the aircraft whilst ATC activated the airport's emergency services.

On leaving the aircraft the commander inspected the wings for ice accretion. He noticed a thin layer of clear, watery ice along the leading edges across the pneumatic de-icing boots from top to bottom. The ice layer could be wiped off with one finger and was no more than one eighth of an inch thick. Throughout the flight there had been no visible signs of ice accretion on the wings or the windscreen wiper. Consequently, the commander had not increased the threshold speed to compensate for ice accretion.

Flight recorder

The aircraft was fitted with a 30 minute recycling Collins 4 channel CVR which was replayed satisfactorily at AAIB. The recording began as the decision was made to divert to Liverpool and confirmed the pilots' recollection of events. There was no stall warning recorded on the CVR and no indication of any engine failure.

Radar data

The Cleve Hill area radar recordings for the G-ZAPC approach, and the four approaches by preceding aircraft were retrieved and a comparison of the approach profiles made. The data showed that GZAPC generally followed the same glide path as the preceding aircraft. The mode C returns from GZAPC indicated that, during the final 80 seconds of radar data, the rate of descent of the aircraft was steady at approximately 500 ft/min.

Calculations of groundspeed based on consecutive radar returns were considered to be less reliable because the range of Cleve Hill from Liverpool Airport is 57 nautical miles. A computer programme was used to smooth the calculated groundspeeds which were then corrected to IAS by applying the best estimate of winds. This showed with a greater degree of confidence that the airspeeds during the approach were consistent with the speeds reported by the crew. The data smoothing technique meant that averaged speeds were not available for the final 30 seconds of recorded radar data.

Aircraft Examination

Prior to examination the aircraft had been removed to a safe area clear of the runway environment. It was apparent that the main structural element of the landing gear had failed in overload and that this had resulted in significant damage to the sponson, but relatively minor damage to the lower right part of the fuselage and right fin and the lower part of the wing strut. Otherwise, the aircraft was undamaged and available for test and examination.

When first seen during the morning following the accident, there was no evidence of ice on any part of the airframe, both altimeters were found set at 1,019 mb, the flaps were positioned at full travel and the nose and left main gears were locked down. Examination of the downlock of the failed gear showed it also to be locked in the down position. Functional tests were conducted, with the assistance of maintenance personnel, of the flight control and gust lock systems with no abnormalities being discovered. With the left engine running at idle, satisfactory functional tests were carried out of the pneumatic boot de-icing system, and correct electrical load demands of the

heaters associated with the anti-icing systems, pitot heads, static plates and stall warning vanes in each wing were observed. Physical checks confirmed the heaters were functioning and that the stall warning sensors operated correctly and would trigger the stick shakers. In addition, leak, blockage and water drain checks were carried out on the pitot-static systems with satisfactory results, with the one exception that the right VSI pointer would stick just above zero when reducing from a positive climb rate indication. Subsequent to these tests, both ASIs, both altimeters and both VSIs were removed from the aircraft and taken for check calibration at an overhaul facility where all were proved to be accurate within normal limits. Slight levels of friction were present in several of these instruments, particularly the right VSI, but this was not noticeable when low level vibration was applied, as is customary, during each test.

Analysis

The LOC DME approach to Runway 09 computed to a 2.83° glide path which is very slightly shallower than the PAPIs 'on glide path' datum of 3° . The difference imparts a small bias towards seeing three reds rather than the expected two reds when on the correct height profile. However, at one mile from touchdown the height difference is 20 feet which is not enough to induce a significant problem, nor does it explain why the commander's altimeter indicated that he was high on the approach when the PAPIs indicated that he was low.

The aircraft manufacturer was asked to estimate a minimum rate of descent that would precipitate failure of the main landing gear structure, if possible where one main landing gear wheel were to touch down significantly before the other, at the aircraft's landing weight of 21,170 lb (maximum landing weight is 22,550 lb). In response the manufacturer stated that, based on static test data, they would expect the rate of descent that could cause failure of a main landing gear leg to be greater than 19.5 ft/sec (1,170 ft/min). If the aircraft was considered to have been in free fall from a height of 30 feet, then its descent rate would have been in the region of 44 ft/sec (2,640 ft/min), and this represents the maximum value in the context of this accident. A normal rate of descent with the aircraft on the glide path, when flown at a ground speed of 90 kt, is some 8 fps (480 ft/min).

Possible causal factors

From the available evidence it appears probable that the aircraft developed a high rate of descent from a height of 20 to 30 feet above the runway without producing a stall warning. The following causal factors were considered: wind shear; wake turbulence; pitot-static system errors; low airspeed during the final stages of the approach; and significant ice accretion on the airframe.

Wind shear was discounted because numerous wind readings showed the normal slight variation in direction but a consistent wind speed, and there were no obstacles such as hangars upwind of the threshold. Wake turbulence was discounted because the preceding aircraft had landed 19 minutes before GZAPC.

The pitot-static systems were checked to be leak free and all relevant instruments were shown to be accurate. It was also established that all pitot head, static plate and stall warning heaters were serviceable. A favourable comparison of the approach profile with those of the preceding four aircraft indicated that there was no evidence of static pressure errors. The calculated airspeeds from radar were consistent with the speeds reported by the crew for the initial approach suggesting that pitot errors were not significant. Thus, unless icing, for example, had affected these systems at a late stage of the approach, erroneous instrument readings were considered unlikely.

The final approach was flown at about the correct airspeed but there was a trend within the radar data, for the last mile of the approach, for the airspeed to reduce towards the stalling speed. However the data was too coarse to provide exact speeds and the stall warning system did not activate.

The likelihood of significant airframe icing was discounted for several reasons including: the commander's statement; photographs taken of the aircraft shortly after the accident which showed no signs of significant ice accretion; no lumps of ice were found on the runway; and the airframe was ice free when examined by the AAIB despite overnight sub-zero temperatures.

There was, therefore, no positive conclusion as to the cause and it remains a possibility that some or all of the above factors, to a small extent, may have combined to produce a high rate of descent while the aircraft was some 20 to 30 feet above the runway.