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 theperiod 1800 hrs to 2400 hrs issued by the Meteorological Officeat 1515 hrs showed cold anticyclonic airflow with winds from theeast. A weak cold front on the surface would extend across theMidlands on either side of which the freezing level would be ator below 1,000 feet amsl and the visibility would be generally15 km. South of the front there would be 2/8 to 6/8cumulus or strato-cumulus cloud between 1,500 and 5,000 feet. North of the front there would be 6/8cumulus or strato-cumulus cloud between 2,000 and 7,000 feet. Moderate icing and turbulence in cloud was forecast on both sidesof the front and ahead of it (to the north) there would be lowcloud and poor visibility due to snow or freezing fog.

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

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

The aircraft departed Exeter at 2237 hrs wherethe weather was fair with scattered cloud at 1500 feet. Afterclimbing uneventfully though cloud to FL 90 the aircraft cruisedin clear, smooth air. In the cruise the co-pilot noticed thathis vertical speed indicator was displaying a slight rate of climbalthough the aircraft was in level flight but this and a spurioushydraulic warning were the only anomalies. As the aircraft approachedEast Midlands airport the runway visual range there was belowthe approach minima and several aircraft were holding awaitingan improvement in the visibility. G-ZAPC descended to 2,500 ftand held in clear air over the Lichfield NDB for about 45 minutesuntil the fuel state dictated a diversion to Liverpool. On diversionthe aircraft was initially cleared direct to the Whitegate NDBand then Wallasey VOR at FL 40. At this level the crew couldsee ground features in good visibility until they entered cloudas they descended through 3,500 feet whilst being radar vectoredfor an approach to Liverpool Airport. The cloud was stratiformin character and did not appear to contain precipitation or significantturbulence. At Liverpool airport the cloud base was 6/8at 1,100 feet, the visibility 12 km, the air temperature +1°Cand the surface wind was 060°/8 kt.

There is an ILS localiser on Runway 09 butno glidepath transmitter so a LOC DME approach is normally flown. Although the DME antenna is mid-way along the runway, the DMErange is set to read zero at the runway displaced threshold. The pilot flies the localiser in azimuth and adjusts his heightaccording to his pressure altimeter; the 3° glidepath commencesat 1,610 feet QNH from 5 nm DME with check heights at 4, 3, 2and 1 nm DME. On the north side of the runway 329 metres fromthe 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 Liverpoolall the anti-icing services were switched on and operating exceptfor the wing de-icing boots which, having seen no ice on the wings,the commander decided not to employ, and the ice detector whichhe considered unreliable. The approach proceeded normally andthe aircraft descended out of cloud at about 1,100 feet havingbeen in cloud for about 10 minutes.

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

The aircraft was cleared to land with a windof "Easterly at 10 kt" and on short finals the commanderasked for full flap. He then allowed the speed to bleed backfrom the approach speed of between 110 and 120 KIAS towardsthe threshold speed of 90 KIAS without moving the throttles fromtheir approach power setting. According to both crew membersand the passenger who was seated in the 'jump seat', the aircraftcrossed over the end of runway at between 88 and 90 KIAS. Some20 to 30 feet above the runway the commander noticed that theflight controls felt 'sloppy' as if the aircraft's speed was unusuallylow 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 aircraftsink rapidly; the commander pulled back on the control columnbut he was unable to arrest the high rate of descent and the aircraftstruck the runway very hard. The right wing dropped as the rightmain gear collapsed

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

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

Flight recorder

The aircraft was fitted with a 30 minute recyclingCollins 4 channel CVR which was replayed satisfactorily at AAIB. The recording began as the decision was made to divert to Liverpooland confirmed the pilots' recollection of events. There was nostall warning recorded on the CVR and no indication of any enginefailure.

Radar data

The Clee Hill area radar recordings for theG-ZAPC approach, and the four approaches by preceding aircraftwere retrieved and a comparison of the approach profiles made. The data showed that GZAPC generally followed the sameglidepath as the preceding aircraft. The mode C returns fromGZAPC indicated that, during the final 80 seconds of radardata, the rate of descent of the aircraft was steady at approximately500 ft/min.

Calculations of groundspeed based on consecutiveradar returns were considered to be less reliable because therange of Clee Hill from Liverpool Airport is 57 nauticalmiles. A computer programme was used to smooth the calculatedgroundspeeds which were then corrected to IAS by applying thebest estimate of winds. This showed with a greater degree ofconfidence that the airspeeds during the approach were consistentwith the speeds reported by the crew. The data smoothing techniquemeant that averaged speeds were not available for the final 30seconds of recorded radar data.

Aircraft Examination

Prior to examination the aircraft had beenremoved to a safe area clear of the runway environment. It wasapparent that the main structural element of the landing gearhad failed in overload and that this had resulted in significantdamage to the sponson, but relatively minor damage to the lowerright part of the fuselage and right fin and the lower part ofthe wing strut. Otherwise, the aircraft was undamaged and availablefor test and examination.

When first seen during the morning followingthe accident, there was no evidence of ice on any part of theairframe, both altimeters were found set at 1,019 mb, the flapswere positioned at full travel and the nose and left main gearswere locked down. Examination of the downlock of the failed gearshowed it also to be locked in the down position. Functionaltests were conducted, with the assistance of maintenance personnel,of the flight control and gust lock systems with no abnormalitiesbeing discovered. With the left engine running at idle, satisfactoryfunctional tests were carried out of the pneumatic boot de-icingsystem, and correct electrical load demands of the

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

Analysis

The LOC DME approach to Runway 09 computesto a 2.83° glidepath which is very slightly shallower thanthe PAPIs 'on glidepath' datum of 3°. The difference impartsa small bias towards seeing three reds rather than the expectedtwo reds when on the correct height profile. However, at onemile from touchdown the height difference is 20 feet which isnot enough to induce a significant problem, nor does it explainwhy the commander's altimeter indicated that he was high on theapproach when the PAPIs indicated that he was low.

The aircraft manufacturer was asked to estimatea minimum rate of descent that would precipitate failure of themain landing gear structure, if possible where one main landinggear wheel were to touch down significantly before the other,at the aircraft's landing weight of 21,170 lb (maximum landingweight is 22,550 lb). In response the manufacturer stated that,based on static test data, they would expect the rate of descentthat could cause failure of a main landing gear leg to be greaterthan 19.5 ft/sec (1,170 ft/min). If the aircraft was consideredto have been in free fall from a height of 30 feet, then its descentrate 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 probablethat the aircraft developed a high rate of descent from a heightof 20 to 30 feet above the runway without producing a stall warning.The following causal factors were considered: wind shear; waketurbulence; pitot-static system errors; low airspeed during thefinal stages of the approach; and significant ice accretion onthe airframe.

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

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

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

The likelihood of significant airframe icingwas discounted for several reasons including: the commander'sstatement; photographs taken of the aircraft shortly after theaccident which showed no signs of significant ice accretion; nolumps of ice were found on the runway; and the airframe was icefree when examined by the AAIB despite overnight sub-zero temperatures.

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