SD3-60 Variant 100, G-BLGB

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Aircraft Type and Registration:	SD3-60 Variant 100, G-BLGB
No & Type of Engines:	2 Pratt & Whitney PT6A-65R turboprop engines
Year of Manufacture:	1984
Date & Time (UTC):	9 February 1998 at 1147 hrs
Location:	Stornoway Airport, Scotland
Type of Flight:	Public Transport
Persons on Board:	Crew - 4 - Passengers - 26
Injuries:	Crew - None - Passengers - None
Nature of Damage:	Left main landing gear collapsed, bottom pivot on right main landing gear shock absorber sheared, rear fuselage underside scraped, tailcone crippled in downward bending, non-structural damage from excessive wing bending
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	49 years
Commander's Flying Experience:	5,300 hours (of which 5,000 hours were on type)
	Last 90 days - 105 hours
	Last 28 days - 38 hours
Information Source:	AAIB Field Investigation

History of flight

The crew were operating their fourth and final sector of the day. The first two sectors had been freight flights from Glasgow to Benbecula and then to Stornoway; the first officer had been handling pilot for these sectors and the aircraft was fully serviceable. Additionally, there were no significant aircraft defects in the technical log. The commander was the handling pilot for the third sector, which was a passenger flight to Benbecula and was uneventful. For the return flight to Stornoway, the commander was again the handling pilot.

This final sector was flown at FL 50, with the aircraft in IMC conditions. The crew noted no indication of ice at this level and the use of the aircraft de-icing equipment was not required. Prior to their approach to Stornoway, the crew contacted ATC and noted the following information: Runway 36 in use, surface wind 260°/ 08 kt, visibility 15 km in light drizzle, cloud few at 800 feet and broken at 1,400 feet agl, temperature plus 7°C and QNH 1002 mb. The commander then briefed for a NDB/DME approach for Runway 36. With G-BLGB still at FL 50, the crew completed the 'Descent' checks and then, when cleared for the procedure completed the 'Approach' checks 'to the line'. The initial approach was normal and the crew were VMC at a range of approximately 8 nm from the airfield. At this stage the commander was certain of his geographical position and, with the agreement of his first officer, decided to continue visually. Although they were in sight of the surface, there appeared to be some patchy cloud in the direction of the airfield and neither pilot could see the runway.

The crew completed the rest of the 'Approach' checks and then did the 'Final' checks down to 'Flaps'; Flap 15 had been selected. By now, the commander was level at his minimum descent altitude (MDA) of 430 feet amsl. Shortly afterwards, the crew acquired visual contact with the runway; the aircraft was to the right of the extended centreline and the crew could see the Precision Approach Path Indicators (PAPI) which were indicating 'four whites'; the commander estimated his range from the runway as one mile. He subsequently recalled that, at the time he considered 'going-around' but, considering the length of Stornoway runway, decided to land. The commander called for "Full flap" and for "Props to max", and manoeuvred G-BLGB to the runway extended centreline. His subsequent approach was based on runway perspective with the intention of touching down beside the PAPIs. During this final approach, the first officer was monitoring the airspeed and initially called out "Plus 10"; this signified a speed of 113 kt based on a VAT of 103 kt. Thereafter, he called "Plus 5", "VAT" and then "Minus 5" before calling for "Power" on several occasions just before touchdown. Neither pilot could remember the PAPI lights during this final part of the approach and the commander did not think that he exceeded 1,000 feet per minute rate of descent. He was certain that the Ground Proximity Warning System (GPWS) had not activated during the final approach. The commander remembers pulling back on the control wheel just before touchdown but that this had no effect on the rate of descent; he also advanced the power levers but the aircraft had landed before any increase in power was apparent. Touchdown was 'Firm' and beside the PAPIs. On landing, there was a 'bang' and the left side of the aircraft went down. G-BLGB slewed to the left and the commander used full right rudder and brake in an attempt to counter this movement. The aircraft came to rest at the left edge of the runway. With the aircraft stopped, the first officer shut both engines down and the commander switched off the 'Electrics'. The commander then opened the door to the cabin and, saw that the rear emergency door at the rear right side was open and the evacuation was in progress; the flight crew followed the passengers out of the door.

Immediately following the landing, the first officer declared a 'problem' to ATC. The controller had been monitoring the approach and noted the apparent lack of a normal flare; following the call from the crew, he immediately activated the 'Crash Alarm'. Within 30 seconds, the AFS had manned their vehicles and had checked in with the controller; the AFS were cleared direct to the aircraft and

arrived there within a minute of the initial call. There was no indication of fire but, with fluid leaking from the right gear, the AFS sprayed the area with foam.

Within the cabin of G-BLGB, the senior cabin attendant had heard a 'very loud bang' on landing and, with the aircraft still moving, called for the passengers to "remain seated with your seat belts fastened". Then, as G-BLGB was slowing down, one passenger informed her that he was a fireman. By now, the aircraft had stopped and, with the normal cabin lights out but the emergency lights illuminated, the fireman opened the emergency door. The senior cabin attendant secured the door open and initiated the evacuation. With the aircraft leaning to the left, it was quite high from the emergency exit to the ground and so the fireman jumped down and helped the passengers from outside while the senior cabin attendant and her supernumerary crew member assisted the evacuation from inside. Once the passengers were all out, the cabin crew moved them away from the aircraft. All the passengers and crew had evacuated by the time the AFS arrived on the scene.

Weather information

An aftercast from The Meteorological Office from Bracknell revealed that there was a frontal system lying northeast to southwest and rippling across the Hebrides. Throughout the area, there was occasional rain or drizzle with a visibility around 10 km, cloud scattered at 700 feet and broken at 1,000 feet agl. The surface wind was 230°/10 kt; at 2,000 feet, the wind was 240°/25 to 30 kt and, at 5,000 feet, the wind was 240°/ 50 kt. Temperature at ground level was plus 8° and minus 1° at 5,000 feet.

With the conditions noted, the Meteorological Office forecaster confirmed that icing was a possibility at 5,000 feet and that moderate wind shear and turbulence was possible close to the surface at Stornoway. However, the flight crew of G-BLGB subsequently confirmed that they had noted no icing during the cruise or descent and that they experienced neither turbulence nor wind shear on approach at Stornoway.

Engineering examination

The first contact of the aircraft with the runway was on the centreline and abeam the PAPIs. The aircraft's track was aligned with the runway and there was no detectable yaw at impact. Ground marks showed that the bursting of the left mainwheel tyre and the collapse of the mainleg had occurred immediately on touchdown and the fuselage, in a slightly nose up attitude, had made heavy contact with the runway. The aircraft bounced for a distance of 46 metres before settling. It then skidded for a further 450 metres before slewing to the left and coming to a halt on the runway.

In the right landing gear, the pin in the lower attachment of the shock absorber to the swinging arm had sheared but the gear had not collapsed. In the left landing gear, the swinging arm had suffered a longitudinal split, initiating at the axle location and travelling towards the shock absorber lower attachment where the fracture line direction began to progress circumferentially. The shock absorber is the lower part of the diagonal brace which folds during gear retraction. This fracture did not develop to full disintegration of the leg but it allowed the axle to rotate upwards under the impact loads and the tyre contacted the diagonal brace at the position of the folding mechanism and downlock. The tyre burst due to damage to its sidewall from this contact, the downlock stop was sheared out and the brace started to fold. Folding of the brace, and retraction of the gear was then resisted by the extension jack which burst under the excess hydraulic pressure. The fracture in the swinging arm was subsequently opened and examined. Detailed analysis showed that the fracture was in overload and no material or processing defects were found.

Functional tests were carried out on each aircraft system whose malfunction could have been a factor in the accident ie the ice detector, flying controls (freedom and range of movement), stall warners and heaters, pitot static system (drains check, leak check and heaters). All operated correctly, although the leak rates in the pitot systems were outside the maintenance manual requirement. From 130 kt, the left system lost 5 kt in 2.75 minutes and the right lost 5 kt in 1.5 minutes; the requirement is for a 5 kt loss in more than three minutes. It is not considered that these leak rates would produce perceptible discrepancies in the ASI indications and they are not considered significant. Furthermore, the systems may have been adversely affected by the impact.

Flight Data Recorder

G-BLGB was fitted with a 30 minute duration cockpit voice recorder (CVR) and a 25 hour duration digital flight data recorder (DFDR). The CVR was fully serviceable and a time history of the cockpit audio for the accident flight was available to the investigation. All parameters, apart from flap, were operational on the DFDR. Recovery of the data was hampered by a poor quality recording (discussions with the repair organisation indicate that the probable cause was that the recording tape was spooled too tightly on the tape transport). The violence of the initial touchdown also caused data to be corrupted. Special techniques permitted all but 0.5 seconds of data at touchdown to be recovered.

Analysis of the recordings show that, up to the final approach, the flight was uneventful and conducted in a professional manner. A graphical plot of the accident approach and landing is attached together with a plot of the previous landing, the same day, at Stornoway; this earlier landing was preceded by a stabilised approach.

Important events from the CVR are annotated on the time history plot of the accident landing. Eighty five seconds before touchdown, ATC were requested to turn up the approach lights. Forty

seconds before touchdown, the runway threshold was sighted; immediately afterwards, the commander expressed doubts as to whether he should continue with the approach. The aircraft then banked to the left and the heading decreased. Twenty three seconds before touchdown, full flap was selected and the propellers increased to fully fine pitch. Torque reduced to approximately zero, the pitch attitude reduced to -8° (nose down), the aircraft banked to the right and the heading increased towards 360°. Six seconds before touchdown, the right bank reached a maximum recorded value of 26°. The pitch attitude increased, airspeed reduced and the ROD exceeded 1,000 feet/min. Then, the aircraft rolled wings level and at touchdown was banked 3° left and pitched 3° nose up. The touchdown 'G' was not recorded because the force of the impact caused the tape transport to accelerate and corrupt the data. At touchdown, the vertical speed was between 1,000 and 1,400 feet/min and the airspeed was about 89 kt. Torque was increasing through approximately 320 lb feet per engine at touchdown and continued to increase for a further 3 seconds. During the final approach, the first officer was calling airspeeds and, on one occasion during a short pause, the commander had asked him to continue giving him speed information. Additionally, leading up to touchdown, the first officer called for power on four occasions and in quick succession.

After the initial impact, the aircraft bounced, pitched nose down and banked left before returning to the ground about 2 seconds later. Thereafter the aircraft decelerated in a nose down and left wing down attitude.

Manufacturer's information

The manufacturer was asked to calculate the rate of descent which, with the aircraft configuration and conditions would result in gear collapse. They estimated that a rate of descent in excess of 960 feet per minute would result in failure of the main undercarriage.

Precision Approach Path Indicators

The PAPIs on Runway 36 are positioned 240 metres from the displaced threshold. A theodolite check of the PAPIs was completed on 29 December 1997 and all the units were found to be within the required tolerances. The report confirmed that, for Runway 36 'four whites' would indicate that the viewing crew were above a 3° 30' glideslope from the PAPIs. On 20 January 1998, an airborne flight check confirmed the accuracy of the theodilite check. Following the accident on 9 February, a further theodolite check was completed on 10 February and this confirmed the accuracy of the PAPIs.

Ground Proximity Warning System

A GPWS activation was recorded on the CVR when the crew were over the sea and descending to their declared MDA of 430 feet amsl. This was a Mode 4A warning which indicates that the aircraft has penetrated the 500 feet agl boundary with the gear not down and locked. The company operations manual requires that: 'When an aural alert occurs immediate corrective action is to be taken to correct the flight path so that the alert ceases. In the case of Mode 4, lowering the landing gear or extending the flaps may be all that is required.' Following the alert, the crew lowered the gear and the associated warning stopped.

The other mode of the GPWS which was relevant as the aircraft approached the ground was Mode 1; this activates when there is an excessive 'Sink Rate' above 50 feet agl. There is an aural warning of "Sink Rate" when the aircraft descends at more than approximately 1,000 feet per minute and an aural warning of "Pull Up" when the descent rate is approximately 1,500 feet per minute; these rates of descent are the boundary limits at 50 feet agl and increase with height. Neither of these warnings were heard on the CVR. The GPWS was functionally checked and found to be operating correctly. Following the accident, the circuit breaker associated with the radio altimeter (radalt), and necessary for the operation of the GPWS, was found to be in the extended position. Since Mode 4A operated correctly, this circuit breaker must have extended after the aircraft was level at MDA and this probably happened as G-BLGB impacted the ground; both crew members confirmed that neither had 'pulled' the circuit breaker.

Although radalt was not recorded, analysis of the available FDR information and the GPWS boundary graphs indicate that the aircraft rate of descent above 50 feet agl was very close to the activation point for Mode 1.

Company procedures

The Company Operations Manual Part 9 includes information on aircraft handling. It includes advice that landing flap should not be selected until the runway is in sight. Additionally, it states that the aircraft is easy to land. The advice on landing technique is based on setting the torque to approximately 1,000 lb feet at 1,300 RPM as the final approach path is intercepted. There is also a comment that, as propeller RPM is increased to 1,675 RPM, the airspeed will decrease if power is not increased.

Discussion of accident

The crew were operating their fourth flight of the day and evidence from the CVR shows that they were working well together and in accordance with the company procedures. Throughout all the flights, the aircraft had been serviceable and the weather had been as forecast. Both crew members

had been to Stornoway before and were familiar with the approach procedures. Prior to descent, they had briefed for the expected procedure and the initial descent was uneventful. At MDA, the crew were in sight of the ground but not visual with the runway; however, they were both familiar with the geographical area and were confident of their position.

Then, at the point that they saw the runway, they could see that the PAPIs were indicating 'Four Whites'. The commander estimated that he was approximately 1 nm from the runway and expressed some doubts as to whether he should continue with the approach; there was no indication from the CVR that the first officer had heard this comment. Subsequently, the commander recalled that, at the time he decided to continue as the runway was long enough to enable him to land further down than normal.

The indication of 'Four Whites' showed that the aircraft was at a descent angle of greater than $3_{1/2}^{\circ}$ from the PAPIs. From the FDR and CVR correlation, G-BLGB landed 40 seconds after the crew sighted the runway. Based on the aircraft's height of 415 feet (MDA less the airfield elevation), this would require an average rate of descent in excess of 600 feet per minute to achieve touchdown at the PAPIs. Complicating factors, which would effectively increase this required descent rate, were that the aircraft was to the right of the extended centreline, at Flap 15 and at approximately 135 kt; the commander had to manoeuvre G-BLGB, configure to landing flap and reduce speed to 113 kt (V_{AT} plus 10 kt).

After the accident, neither crew member could recall the PAPI indications during the final approach; the commander based his approach on runway perspective. After sighting the runway, he called for landing flap, reduced his power levers to idle and commenced his descent while manoeuvring to the runway centreline. During the subsequent final approach lasting just over half a minute, the commander gained the normal approach path but at the expense of idle power and a decreasing airspeed; the increase in propeller speed without any increase in engine torque accentuated this decrease in airspeed. The first officer complied with the company procedures and reported the airspeed to the commander; he also called for more power just before touchdown. At touchdown, the commander was advancing the power levers but the engines had achieved no significant power before impact. The minimal slipstream effect from the propellers together with the low airspeed resulted in little change in aircraft attitude when the commander made an elevator demand. The rate of descent at touchdown was in excess of that at which the gear would collapse.

The subsequent reaction by ATC and the AFS was very rapid and reflects credit on the individuals concerned and on the emergency procedures.