INCIDENT

Aircraft Type and Registration:	Boeing 767-2Q8, N330LF
No & Type of Engines:	2 General Electric CF6-80C2 turbofan engines
Year of Manufacture:	1989
Date & Time (UTC):	8 November 2006 at 1329 hrs
Location:	Bristol (Filton) Aerodrome
Type of Flight:	Commercial Air Transport (Non-Revenue)
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Left main landing gear door missing, hydraulic sytem failure
Commander's Licence:	Air Transport Pilot's Licence
Commander's Age:	56 years
Commander's Flying Experience:	7,536 hours (of which were on type) Last 90 days - 115 hours Last 28 days - 45 hours
Information Source:	AAIB Field Investigation

Synopsis

The aircraft was making a ferry flight from Nimes into Filton Aerodrome, Bristol, to be repainted. During taxi after landing at Filton the right hydraulic system was lost and centre system fluid quantity and pressure indications began to reduce. After reaching the stand it was observed that the left landing gear door was missing and that the hydraulic brake pipes on the landing gear leg had been severely damaged. A large portion of the landing gear door was recovered from the garden of a house in Chippenham, over which the aircraft had flown. Investigation revealed that the door had been released due to the failure of a castellated nut on the bolt associated with the door 'mid mount'. The door had been installed and rigged immediately prior to the ferry flight.

History of the flight

The aircraft had undergone maintenance in Nimes prior to entering service with a new operator, during which both of the main landing gear units were removed, overhauled and reinstalled. After completion of the maintenance input, the aircraft was to be ferried to Filton to be painted in the livery of the new operator. The flight crew reported that, on takeoff, the landing gear failed to retract on its first selection but, on reselecting the landing gear to UP and pressing the 'gear override' button, it retracted. After an uneventful flight, the flight crew decided to lower the landing gear early on the approach to Filton to allow time to assess any problems which may have arisen. The landing gear was selected to DOWN at approximately 8,000 ft and no problems

were observed with its deployment. However, after a normal landing and when leaving the runway, the flight crew observed that the right hydraulic system fluid quantity and pressure were reducing. After three minutes, the right system pressure had fallen to 20 psi; the centre hydraulic system quantity and pressure then also began to fall. The flight crew reported that braking and steering remained normal until the aircraft reached its assigned stand and came to a halt. As the aircraft pulled onto the stand, the ground crew waiting to receive the aircraft observed that the left landing gear door was missing and that hydraulic fluid was leaking from the rear of the landing gear leg.

Landing gear door installation

The landing gear door is fitted with four attachment brackets which secure it to the landing gear leg; 'upper rod' and 'mid door' attachments, forward of the leg, and 'lower rod' and 'lower door' fittings, aft of the leg, Figure 1. As the names imply, both the upper and lower rod fittings make use of adjustable eye-ended rods to secure the door to lugs on the landing gear leg. The mid door attachment makes use of a nut and bolt to secure the door to a lug on the leg, and the lower attachment uses a short threaded eye-end rod and nut to secure the door to the lower rear mounting lug. When installed, the lower rod passes between the rear face of the landing gear leg and the wheel brake hydraulic pipes. The brake system is fitted with four hydraulic fuses, one in each pressure supply pipe, which are designed to shut off the hydraulic supply to individual brake units should a significant leak occur.

The procedure for installing and rigging a landing gear door is described in the Boeing 767 Maintenance Manual, task 31-12-06-404-011. This details the adjustment of the rod eye ends and the addition of spacers between the lugs on the leg and the mid and lower door fittings. This process requires the aircraft to be jacked up and landing gear to be retracted, to determine what adjustments, if any, are required. This is intended to ensure that the landing gear door maintains the correct clearance with the lower surface of the wing and is not subject to abnormal loads, either in flight or during retraction of the landing gear.

Boeing Service Bulletins

Since its entry to service, there have been several instances of landing gear doors becoming separated from Boeing 767 aircraft. In response to these events Boeing have issued four Service Bulletins:

Alert Service Bulletin (ASB) 767-32A0051

Issued in September 1985 and revised on October 1985, January 1986 and March 1997, this ASB introduced an inspection of the door mounting hardware and, as terminating action for the inspection, required the replacement of the originally installed nuts and bolts with items of improved strength.

Service Bulletin (SB)767-32-0101

Issued in January 1992 and revised in September 2003, this SB introduced a replacement lower aft attachment fitting.

Service Bulletin (SB)767-32-0146

Issued in March 1997 and revised in September 2003, this SB introduced a new mid forward door fitting together with the replacement nuts and bolts introduced by Alert Service Bulletin 767-32A0051.

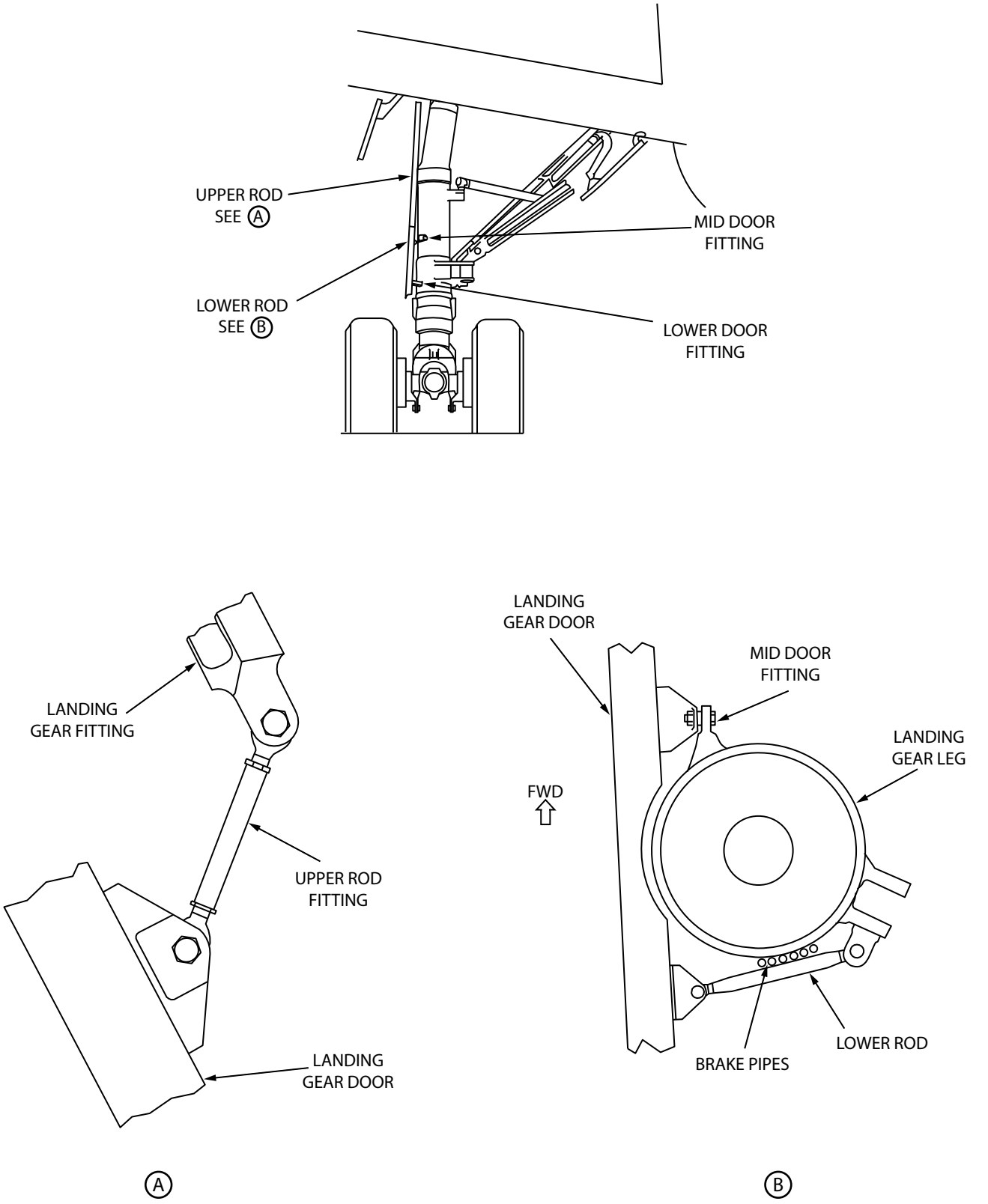

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Figure 1

Taken and adapted from:
Shock Strut Door and Linkage Installation for the Main Landing Gear (Figure 401 32-12-06)

Service Bulletin (SB)767-32-0194

Introduced in July 2002 and revised in September 2003, this SB replaced the mid forward and lower aft mounting hardware.

The aircraft maintenance records identified that only ASB 767-32A0051 had been incorporated on N330LF.

Flight Recorders

The aircraft was fitted with a Solid State Flight Data Recorder (FDR) and a Cockpit Voice Recorder (CVR). The FDR recorded over 100 hours of operation, including the incident, but the 30 minute CVR had continued to run and audio data covering the approach and landing had been overwritten.

At 14:20:17, the aircraft was descending through 8,000 ft when the landing gear was selected to DOWN. At the time of extension, the aircraft was decelerating through a Computed Airspeed (CAS) of 249.5 kt, with the speed brakes deployed. All landing gear legs were locked down 16 seconds later. The missing door was discovered at a location around 2 nm from the recorded aircraft position at landing gear extension, some 22 nm from the runway at Filton.

The aircraft touched down just over nine minutes later, at an airspeed of 127 kt. The left, centre and right hydraulic system pressures all indicated around 3,000 psi at that time and, just prior to touchdown, the fluid quantity in the right hydraulic system indicated 110%. (This parameter along with all other hydraulic quantities and pressures are only recorded every 64 seconds so only a trend can be determined.)

At 14:30:30, 52 seconds after touchdown, at a ground speed of 22 kt, the right hydraulic system quantity had decreased to 94% and continued to decrease as the aircraft taxied. Three minutes later, with the right hydraulic system quantity reading 30%, system pressure began to decay, finally reaching 0 psi three and a half minutes later. The system low pressure 'discrete' indication was triggered two minutes 45 seconds after the decay had started, at a pressure of around 1,000 psi. Subsequently, a reduction in the fluid quantity of the centre hydraulic system was observed, reducing from 82% to 65% just before the recording ceased. The final recorded hydraulic pressure of this system was 2,892 psi.

Technical examination

Examination of the aircraft revealed minor damage to the lower wings skins, the landing gear bay and the landing gear trunnion door; no other damage caused by the release of the door was observed on the aircraft structure. Visible damage to the landing gear leg was confined to the steel inserts pressed into the door attachment lugs. Approximately 10% of the landing gear door remained attached to the leg by the lower rod, the remainder having departed the aircraft prior to landing. Six hydraulic pipes, secured to the rear of the landing gear leg, had been bent and crushed by the rod, Figure 2, and two of the hydraulic fuses, those for the two rear brake units, were found to have operated.

The rod from the upper attachment, complete with the bolt and inserts from the door attachment bracket, were still attached to the landing gear leg. The remains of the lower door attachment, consisting of the threaded portion of the shank, complete with its castellated nut and cotter pin, were found on the landing gear bogie.

A bolt from the mid door attachment was recovered from the stand, which exhibited a degree of damage to the threads and which contained the remains of a cotter pin, Figure 3. With the exception of some minor bending and scoring of the shank, the bolt had not

Figure 2

suffered from any deformation and remained within manufactured dimensional tolerances. The threads of the bolt were free from contamination, evenly spaced and of uniform depth.

The remains of the landing gear door, comprising a section 1 x 1.7 m, and weighing approximately 15 kg, was discovered in the rear garden of a house in Chippenham by the house owner. Fortunately, the door had not caused any damage or injury to anyone on the ground. Three of the door attachment brackets, the upper rod, mid door and lower door attachments, remained securely fastened to the door. The upper rod mounting bracket had failed across the bolt holes, allowing the rod, complete with mounting bolt, to be released. The damage to the fitting and the nature of the fracture surfaces indicated that it had failed due to an overload condition in bending. The lower door attachment bracket still held the eye-end of the rod used to secure the door bracket to the landing gear. When the two sections of the rod were placed together, it indicated that the shank had been bent rearwards by 38º before it failed. Analysis of the geometry of the lower rod attachment hardware showed that, in order to come into contact with the hydraulic pipes, the rod must be rotated aft by 32°.

A comparison of the part numbers of the attachment hardware confirmed that the modification standard of the aircraft complied with the requirements of Boeing ASB 767-32A0051, but not subsequent Bulletins.

After the brake pipes had been repaired, the aircraft was flown to Nimes for replacement of the landing gear door. No further defects were reported during the retraction of the landing gear on this or subsequent flights.

Maintenance records

A review of the work-pack held by the organisation that carried out the landing gear removal and re-installation, confirmed that all of the landing gear units had been removed and refitted in accordance with the procedures detailed in the appropriate Boeing Aircraft Maintenance Manual. An investigation into the event conducted by the maintenance organisation commented that there had been some difficulties in rigging the landing gear, which required approximately ten retraction and extension cycles to be carried out prior to achieving a satisfactory result.

Figure 3

Analysis

Hydraulic systems

The hydraulic lines on the landing gear leg remain depressurised until the application of braking, therefore despite being damaged when the aircraft was airborne, the loss of hydraulic fluid would have been relatively slow until the aircraft had landed and the brakes were applied.

Although no braking parameters were recorded on the FDR, following the loss of the right hydraulic system, the braking system should automatically have switched to ALTERNATE, which is supplied by the centre hydraulic system. As the alternate and normal braking systems use the same hydraulic supply pipes to the brakes, fluid would have continue to leak from the damaged pipes, leading to the subsequent reduction in centre system fluid quantity as the brake system operated.

Door failure

Information from the flight data recorder revealed that the landing gear had been lowered at an airspeed close to, but below, the maximum allowable for its deployment. In flight, with the landing gear extended, aerodynamic forces apply both drag and side loads to the door. A crosswind component or aircraft manoeuvring would have a significant effect on the loads acting on the doors. Given their location, the door mounts forward of the landing gear leg would tend to experience tensile loads in addition to the drag load, and those to the rear, compressive loads, but such loading should not have caused the door to fail.

The remains of the cotter pin and the lack of distortion to the mid-fitting bolt indicated that the nut fitted to this bolt had failed due to a tensile overload. The loss of the nut would have precluded the mount from carrying tensile load, and all such loads would then have to be carried by the remaining forward mount. The damage observed on the upper rod fitting confirmed that it had been subject to tensile loading and, to a lesser degree, bending, prior to failure. Given the lack of distress to the mid-mount bolt and the damage observed to the remaining mounting hardware, it is considered probable that the loss of the landing gear door was initiated by the failure of the mid-mount nut.

The degree of distortion to the lower door mounting hardware, and the degree of rotation needed to bring the lower rod fitting into contact with the hydraulic pipes, left little doubt that both of the forward mounts, the upper rod and mid door attachments, must have failed in order to allow the landing gear door to rotate in such a manner.

The door mounting hardware fitted to the aircraft was compliant with the requirements of Boeing ASB 767-32A0051. A review of the other SB's relating to improvements in the landing gear door attachments showed that, although improved door mounting brackets had been introduced, the nut and bolt securing the mid mount to the landing gear leg remained unchanged until the release of SB 767-32-0194 in 2002. This was when the bolt was superseded. However, the part number of the nut securing this bolt remained the same as that introduced by ASB 767-32A0051. Given that the door attachment fittings remained securely attached, and that the initiation of the door loss resulted from the failure of the nut on the mid-mount bolt, the fact that the three later SB's had not been embodied is not considered to have been a factor in this event.

The report from the maintenance organisation stating that numerous landing gear retractions were required to rig the door gave rise to the possibility that the

door mounting hardware, and the mid-mounting bolt in particular, may have been subject to unusual loads during the process.

Conclusions

The loss of the landing gear door was initiated by the failure of the castellated nut on the door mid-mount fitting. Whilst the speed at which the landing gear was deployed was higher than that expected in routine operation, it was within the aircraft's landing gear limit speed, and was considered unlikely to have initiated the nut failure.

Given that the part number of the castellated nut fitted to the door mid-mount remained the unchanged in the Service Bulletins released after SB 767-32A0051, the modification standard of the door mounting hardware is also unlikely to have been relevant to the loss of the landing gear door.

However, the possibility that the failure of the nut resulted from overload during the repeated landing gear retractions carried out during the door rigging procedure prior to the incident flight, could not be dismissed.