AAIB Bulletin No: 2/95 **Ref: EW/C94/8/3** **Category: 1.1**

INCIDENT

Aircraft Type and Registration:	Boeing 747-236B, G-BDXH
No & Type of Engines:	4 Rolls-Royce RB211-524D4 turbofan engines
Year of Manufacture:	1979
Date & Time (UTC):	30 August 1994 at about 1455 hrs
Location:	En route to Lagos, Nigeria
Type of Flight:	Public Transport
Persons on Board:	Crew - 16 Passengers - 173
Injuries:	Crew - None Passengers - None
Nature of Damage:	Disintegration of a left wing trailing edge panel and consequent damage to the upper surfaces of the mid- and fore-flaps
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	49 years
Commander's Flying Experience:	9,200 hours (of which 3,300 were on type) Last 90 days - 125 hours Last 28 days - 36 hours
Information Source:	AAIB Field Investigation

History of the flight

The aircraft, which left London Gatwick Airport at 1226 hrs, was in the cruise, at FL290 and M0.84, on a scheduled flight to Lagos, Nigeria. Vibration was reported from the area around the centre galley; it was described as a 'rumble' and appeared to come from beneath the cabin floor. It was initially thought that it might be a problem with the air conditioning system and the crew's diagnostic processes started from this assumption. Whilst this was in progress the aircraft climbed to FL310. A passenger noticed that a part of a left wing panel had separated and reported the fact to a member of the cabin staff, who relayed it to the commander. The vibration had increased in intensity and the flight engineer went into the cabin. Through a window, he saw that a section of upper wing panel, about 4 feet by 2 feet, was missing and the hole was enlarging as smaller pieces of panel became detached; it was also evident that some damage to the flap had occurred.

The commander decided to return to Gatwick and the aircraft was slowed and descended to minimise further damage. No handling problems were experienced and the vibration had largely abated by the time the speed had been reduced to M0.6. Being aware that some damage had been done to the flap, the commander left his options open to divert to London Heathrow Airport which was more suitable for a flapless arrival. After 27,000 kg of fuel had been jettisoned, Flap 1 was selected as the aircraft approached the coast, followed by Flap 5. There were no problems with either the flap deployment or the subsequent handling characteristics and so the commander decided to continue with the Gatwick arrival for a 25° flap landing. The approach was uneventful, and the aircraft landed safely at 1918 hrs.

Human factors

The flight crew were well balanced in age and experience and had all contributed to the safe conclusion of the flight; the valuable contribution of the cabin staff was also noted. The commander commented on the value of the Line Orientated Flight Training (LOFT) and Crew Resource Management (CRM) training they had received.

Engineering examination

The aircraft was examined on the ground at Gatwick and the subject panel was subsequently removed for detailed inspection in a laboratory. The panel in question was part number 654U6075-1561 and formed part of the fixed wing trailing edge above the inboard flap. It was constructed of glass fibre skins around a paper honeycomb (Nomex) core. During flap retraction, the panel is deflected upwards by the passage of the inboard mid-flap bearing on its underside at the inboard end. It can be appreciated that the panel is therefore subjected to bending stresses due to this mechanism. As the panel progressively disintegrated, considerable damage had been caused to the upper surfaces of the mid- and fore-flaps (see photograph). In fact, the damage was almost identical to that suffered by another Boeing 747 aircraft, G-TKYO, on 25 May 1992. This aircraft also lost the trailing edge of an identical panel in-flight and a detailed report of this incident may be found in the AAIB Bulletin 8/92.

The subsequent examination showed that the panel from G-BDXH had been the subject of a sizeable repair covering about 18 inches of the trailing edge chordwise and extending over about two-thirds of the span from the inboard end. The honeycomb core had been replaced in this region, the interface with the old core being filled with a foaming adhesive. The inner skin had also been replaced and several overlapping plies applied where it met the original skin. The operator's records showed that this repair had been done in February 1991 due to the discovery of extensive delamination following a

crew report of vibration. The repair scheme adopted was designed and executed by the operator using a general process devised in 1979 and subsequently used successfully on many composite structures. It is understood that the need for such a scheme was necessitated by a lack of suitable guidance in the manufacturer's Structural Repair Manual (SRM) at that time. This repair did not follow the Boeing SRM extant in 1991 in many respects but clearly the operator felt their own scheme had proved itself adequate and was suitable for this application.

The AAIB examination of the failed panel noted that the fracture surface largely followed the repair splice but there was no evidence of substandard workmanship involved with the repaired areas which remained. The examination report concluded that the panel had probably failed due to the nature and size of the repair, which increased the stiffness locally and transferred bending and torsional loads into that area, leading to cracking and disbonding.

Boeing Structural Repair Manual

The Boeing Company were approached for their views on the above conclusion. Their reply confirmed the fact that they had not been contacted for comment on this particular repair at the time it was done. However, given the size and location of the repair, they stated that had it been sought, approval would only have been granted if it was regarded as temporary with an 18 month maximum time-in-service but ideally the panel should have been replaced as soon as a spare became available. During this period, they would have specified repetitive monthly visual and NDT checks.

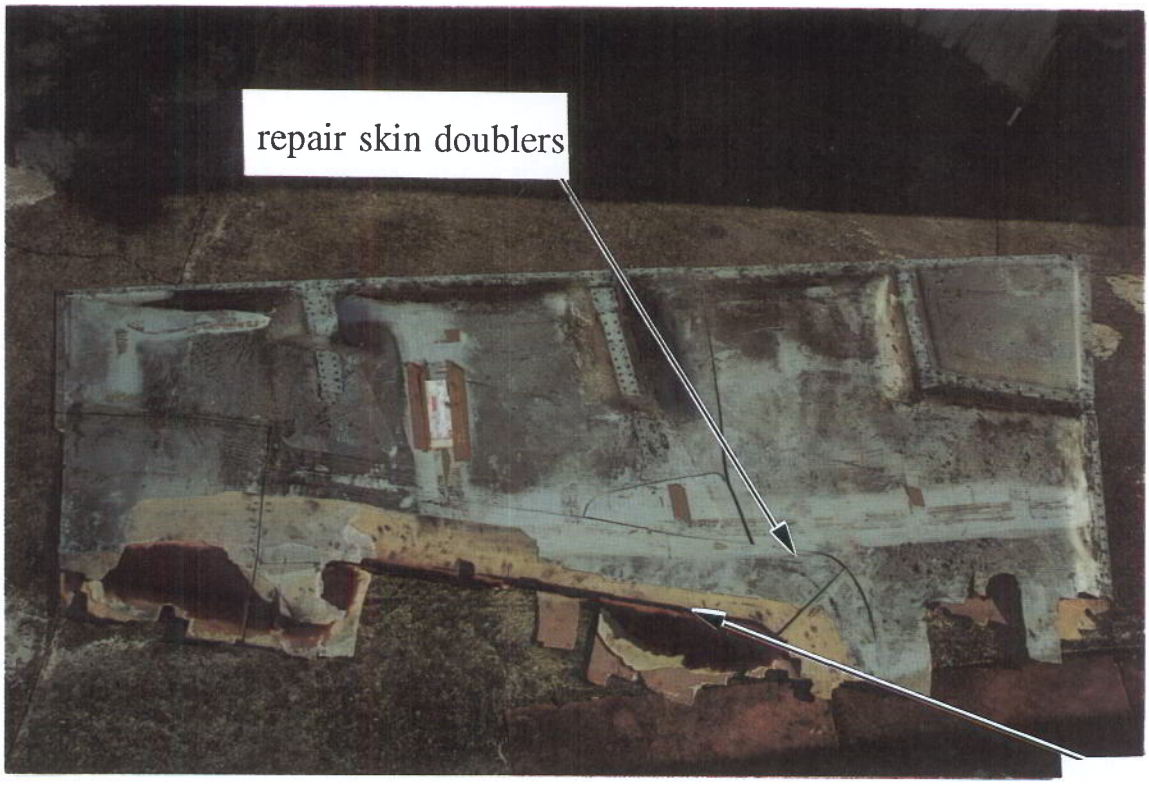
Boeing disagreed that a repair scheme adhering to their SRM would necessarily locally change the stiffness characteristics and opined that an increase in spanwise stiffness would not significantly change the overall loading in the panel. They pointed out that they had no knowledge of the scheme used on the panel in question and were reluctant to comment on the AAIB conclusion as they had not examined the parts involved. At the time of the repair the SRM gave a variety of options for method depending on the size of the damaged area. The large size of this repair would have required the use of pre-impregnated materials and a 250°F cure temperature but no limitation on size was applied if this method was followed.

In August 1994 the SRM was revised to restrict the maximum area of a repair to 288 square inches, even using the most stringent methods.

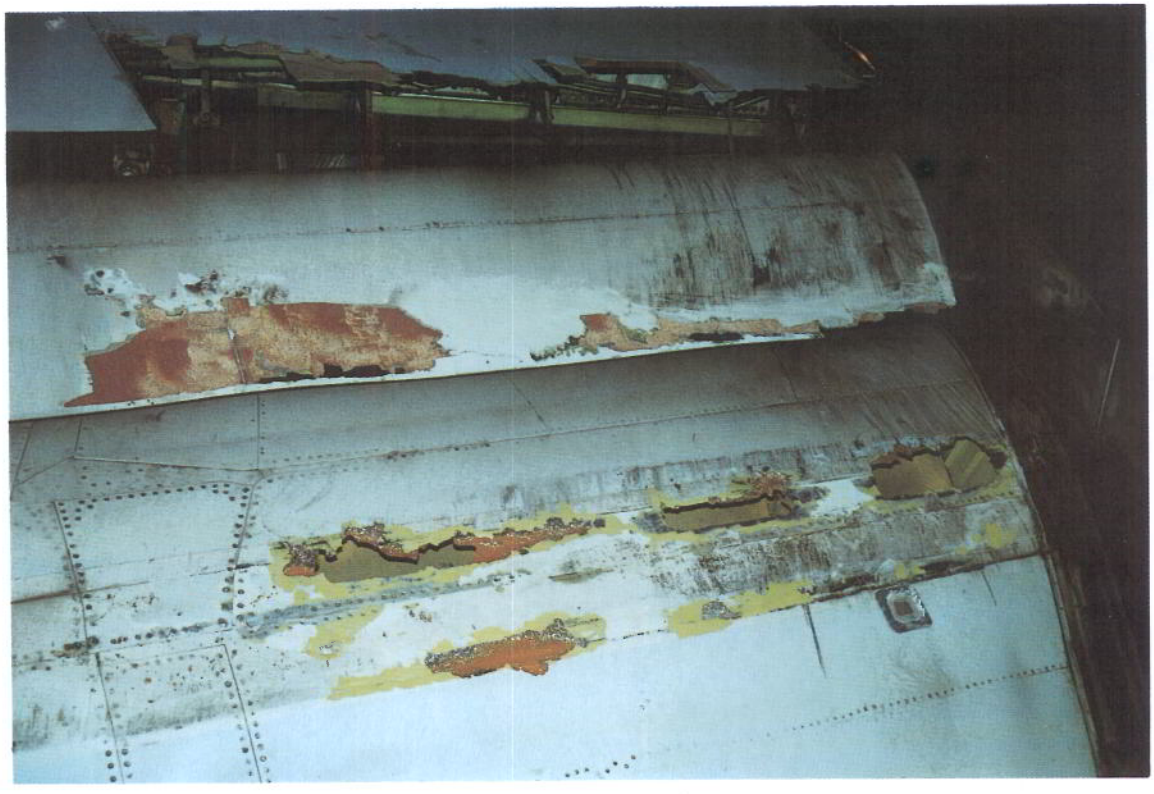
Additional information

The problem of failure or incipient failure of Boeing 747 fixed trailing edge upper inboard panels has been widely experienced, with more than 100 cases recorded by Boeing. Even loss of large portions, such as occurred on G-BDXH, seems to have minimal effect on aircraft performance and controllability but the two cases investigated by AAIB both resulted in significant damage to the inboard flaps.

Possible additional reasons for delamination include the ingress of moisture into the bonded materials or misrigging. The above-mentioned report in AAIB Bulletin 8/92 gave details of various changes to the rigging requirements promulgated by Boeing through Maintenance Manual revision and Service Bulletins (SB). In July 1994, Boeing issued SB 747-57-2289 which gave operators the option of purchasing a new panel offering 'improvements in manufacture, durability and serviceability'. Accomplishment of the latter negated the requirements for repeat inspections of the old panel introduced by SB 747-57-2261. Although it is understood that the latter SB was actioned on G-BDXH, it would appear that the inspection interval not exceeding 600 flight cycles was inadequate to prevent failure of this particular repaired panel.



G-BDXH - View of failed wing trailing edge panel showing repaired area



G-BDXH - Damage to mid-and fore-flap due to break-up of trailing edge panel