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## Engine damage in climb, Boeing 747-236B, G-BDXH, 21 May 1996

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**Micro-summary:** A Boeing 747 was hit by lightning on the #4 engine, resulting in a Cowl Overheat light and a return to the origin.

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**Event Date:** 1996-05-21 at 1118 UTC

**Investigative Body:** Aircraft Accident Investigation Board (AAIB), United Kingdom

**Investigative Body's Web Site:** <http://www.aaib.dft.gov/uk/>

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# Boeing 747-236B, G-BDXH, 21 May 1996

## AAIB Bulletin No: 4/97 Ref: EW/C96/5/9 Category: 1.1

<b>Aircraft Type and Registration:</b>	Boeing 747-236B, G-BDXH
<b>No &amp; Type of Engines:</b>	4 Rolls Royce RB211-524D4 turbofan engines
<b>Year of Manufacture:</b>	1979
<b>Date &amp; Time (UTC):</b>	21 May 1996 at 1118 hrs
<b>Location:</b>	20 nm southwest of London Gatwick Airport
<b>Type of Flight:</b>	Public Transport
<b>Persons on Board:</b>	Crew - 19 - Passengers - 186
<b>Injuries:</b>	Crew - None - Passengers - None
<b>Nature of Damage:</b>	Fin tip cap destroyed, No 4 powerplant components damaged
<b>Commander's Licence:</b>	Airline Transport Pilot's Licence
<b>Commander's Age:</b>	50 years
<b>Commander's Flying Experience:</b>	15,105 hours (of which 7,064 were on type) Last 90 days - 108 hours Last 28 days - 62 hours
<b>Information Source:</b>	AAIB Field Investigation

## History of the flight

The aircraft took off at 1113 hrs from Runway 26L at Gatwick, bound for Lagos (Nigeria). The aircraft was cleared on a BognalM Standard Instrument Departure, which involved climbing straight ahead initially for 4 nm before turning left onto a southerly track, climbing to 5,000 feet altitude. At the start of the left turn, ATC requested the aircraft to take up a heading of 230° for traffic separation. The flight crew requested a turn onto 240° to avoid weather. The Flight Data Recorder (see below) indicated that engine anti-ice on was selected for all four engines at around this time. The aircraft was then cleared to climb to 6,000 feet altitude.

As the aircraft reached 6,000 feet there was a loud bang as the aircraft was struck by lightning in the region of the No 4 powerplant, after which the 'COWL OV HT' (Cowl Overheat) amber caption

illuminated on the centre panel. A similar caption also appeared for the No 4 engine on the pilot's overhead panel. The aircraft continued a normal climb and proceeded on the planned route.

Company maintenance control was contacted by radio. Some diagnostic checks were carried out on the system and it was confirmed that the No 4 engine Cowl Anti-Ice system was inoperative. As thunderstorms and icing conditions were forecast further down the route, the commander decided to return to London Gatwick Airport. In consultation with French ATC, a right turn was commenced at FL330, just south of Limoges, at 1219 hrs.

Some 2,000 kg of fuel was dumped during the return in order to be comfortably below maximum permitted landing weight. While approaching Mayfield VOR during the Gatwick Standard Arrival, the crew became aware that both the No 1 and 2 VHF Navigation receivers were inoperative, and they were thus unable to receive the ILS Localiser signal. Glidepath indications were normal. A radar monitored visual approach was carried out to Runway 26L, where the aircraft landed uneventfully at 1338 hrs. After landing it was observed that most of the fin tip cap was missing.

The crew filed a company Air Safety Report and transferred across to another aircraft to operate the flight, which finally departed for Lagos at 1651 hrs.

An aftercast from the Meteorological Office indicated that, at the time of the lightning strike, a cold front was just clearing Kent with an unstable westerly airstream being established over Sussex and Kent. The Meteorological Office radar showed one storm cell 10 nm south of Gatwick at 11:20:23 hrs. A thunderstorm was also reported at Manston, Kent at 1100 hrs.

## **Flight Recorders**

The aircraft was fitted with a Cockpit Voice Recorder (CVR), a Flight Data Recorder (FDR) and an Optical Quick Access Recorder (OQAR). The circuit breaker for the CVR had not been pulled following the lightning strike and so the audio recordings of the entire flight had been overwritten. The FDR was removed from the aircraft and replayed at AAIB and the OQAR optical disk was removed and replayed by the operator. Both recordings contained all of the incident flight.

Replay of the FDR showed that at 1118:12 hrs, as the aircraft climbed through 5900 ft at 286 kt, the FDR recorded an incorrect time for a period of 4 seconds. Data synchronisation was not lost and this was the only evidence of an electrical disturbance in the FDR recording system. At the same time the OQAR lost data synchronisation for a period of 5 seconds and then recorded the same incorrect time as the FDR for a further 4 seconds. Following the recovery of data synchronisation, the OQAR showed an engine No 4 cowl overheat warning and that engine anti-ice on engine No 4 had been set to off. In addition, the electrical outputs from the localiser No 1 and No 2 systems decayed to give readings of zero. No degradation of engine performance was detectable subsequent to the above events nor were any abnormal aircraft handling characteristics observed. None of the three ILS systems on the aircraft was used for the approach.

## **Aircraft Description**

The top of the fin (Figure 1.1) is formed by three fairings (Figure 1.2) bolted to the upper edge of the aluminium skin of the main part of the fin, immediately above the topmost rib of the fin. A composite tip cap forms the main component; to this is riveted an aluminium leading edge fairing and an aluminium trailing edge fairing. The tip cap is of sandwich construction and consists of 0.38 inch thick plastic honeycomb bonded between an inner and an outer glass reinforced plastic

(GRP) epoxy skin. An aluminium diverter strip of 1.25 x 0.085 inch cross section is riveted along the top of the fin cap and to the top of the leading and trailing edge fairings. The Maintenance Manual (Chapter 236100, Figure 1, Flagnote 4) showed 3 wick-type static dischargers mounted on the diverter strip. A twin VOR/LOC antenna of aluminium construction, serving No 1 and 2 systems, is mounted on the top rib of the fin beneath the fin cap. Access to the antenna is provided by a 20 x 10 inch cut-out in the right side of the tip cap, covered with a GRP access panel retained by steel screws.

## **Aircraft Examination**

Marks were evident on the lower outboard part of the No 4 engine cowl, probably consistent with a lightning strike but without appreciable damage except for detachment and loss of the small starter valve access panel from the cowl.

Virtually all of the fin tip trailing edge fairing and much of the tip cap (approximately 70%) were missing (Figure 2.1), including the VOR/LOC antenna access panel. The cap generally had fractured immediately above the fin attachment flange; signs of slight localised overheating were evident in the area of several of the screw fasteners in this area. The forward part of the cap remained in situ, together with the leading edge fairing and the whole of the diverter strip, which remained bolted to the leading edge fairing. The leading edge fairing had suffered minor deformation consistent with the effects of a forward overload applied in the region of the diverter strip attachment.

The VOR/LOC antennas had been considerably damaged, with the forward part broken up, heavily distorted and severely blackened (Figure 2.2). The two signal cables from the antenna had sustained severe overheating damage in the fin cap area.

A lightning strike inspection by the operator revealed no other evidence of strike damage to the aircraft.

It was noted that there were no attachment holes for static dischargers present in the fin tip cap diverter strip and the evidence showed that none of the 3 static dischargers specified in the Maintenance Manual had been fitted. The operator did not believe that the presence of these static dischargers, intended to reduce radio receiver interference, would have any relevance to the likelihood of experiencing a lightning strike or to the severity of the damage if a strike occurred.

Investigation of the aircraft systems identified a short circuit in the overheat detector transducer for the No 4 powerplant nose cowl, damage to the No 4 engine cowl anti-icing circuit and an electrical breakdown in the circuit for the oil temperature indicator. No other damage to aircraft systems was found by the operator. No evidence of damage to the VOR/LOC receivers was found and the aircraft returned to service with the same receivers installed.

## **History**

Boeing Service Bulletin 747552027, issued 16 May 1986, concerned reduction in the likelihood of lightning strike damage to the 747 tip cap area. The Bulletin summary included:

"BACKGROUND: The accomplishment of this modification will reduce the possibility of damage to the VOR antenna and fin tip cap structure caused by lightning strike.

Eleven operators have reported 23 instances of VOR antenna damage resulting from lightning strikes. Lightning strikes have caused varying degrees of damage from small pit marks on the antenna elements up to almost complete destruction of antenna elements, coax cables, and fibreglass honeycomb fin tip cap structure. The path of lightning penetration to the antenna is suspected to be the antenna access door metal fasteners.

A sustained lightning strike could cause the VOR system to be inoperative and require repair or replacement of the fin tip assembly before the next flight."

The modification involved the removal and discarding of the VOR access panel fasteners from the forward, upper and aft edges of the panel and the attachment of the panel by adhesive bonding. Three vertical diverter strips were then to be bonded with adhesive to each side of the cap in the region of the VOR antenna (Figure 1.3). The Bulletin listed the kit cost as US\$590 and the total labour requirement as 10 manhours. A consequence of incorporating the modification would be that the whole fin tip cap would need to be removed to gain access to the VOR/LOC antennas.

The modification was optional and the operator had reportedly rejected it because of the low frequency of lightning strike damage to the VOR/LOC antennas and fin tip structure. The operator also considered that, while the additional diverter strips may assist in reducing damage, they would not preclude all damage, particularly from powerful strikes. It had not been incorporated on G-BDXH.

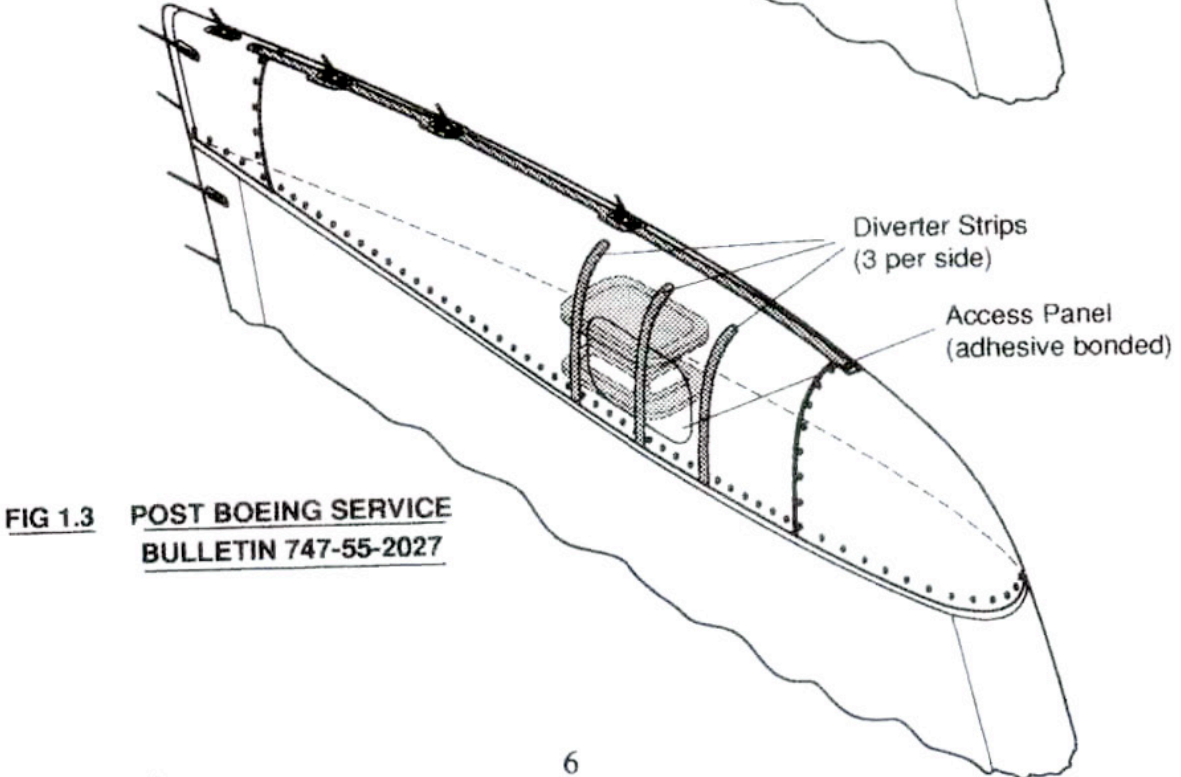
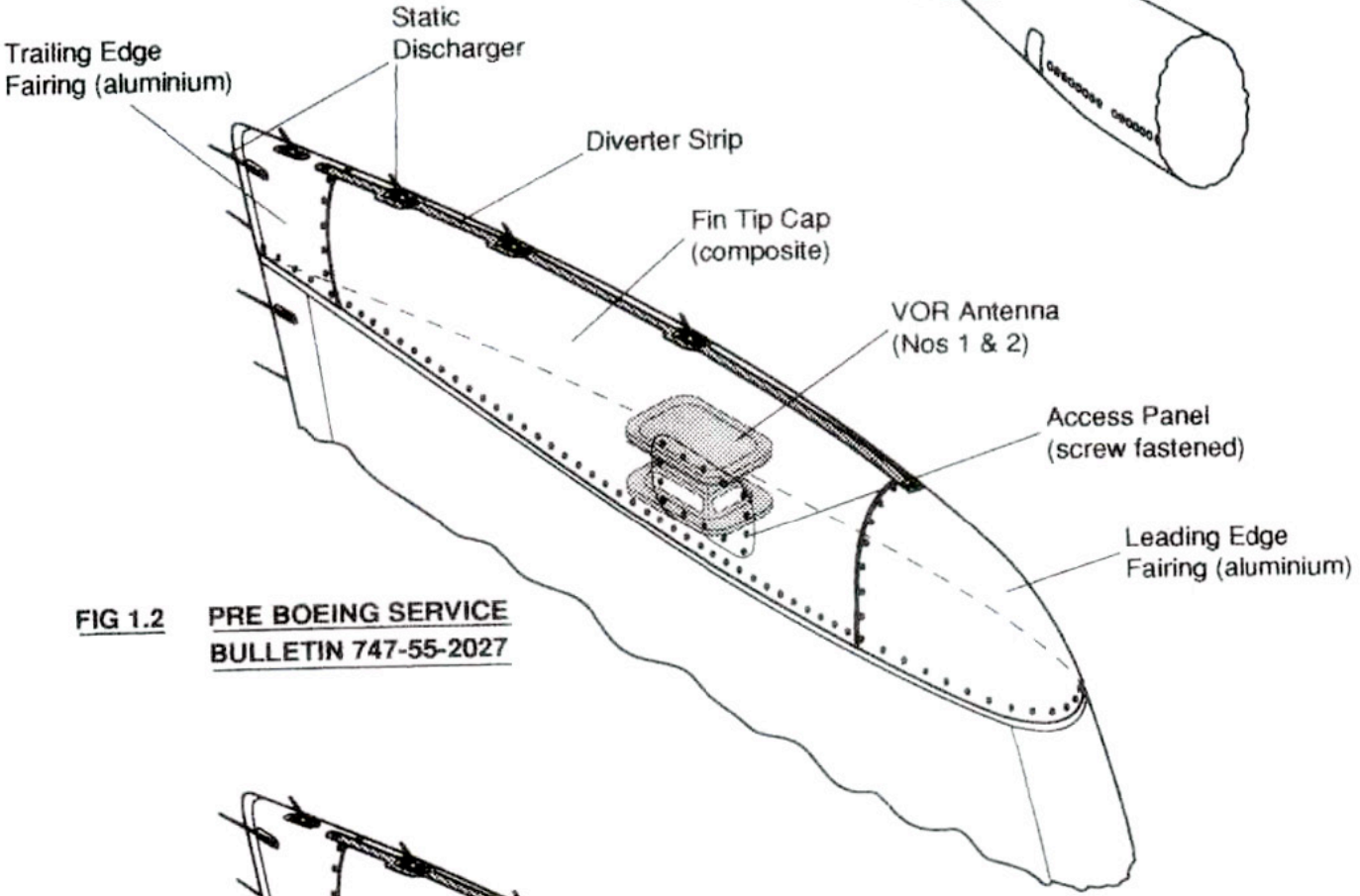
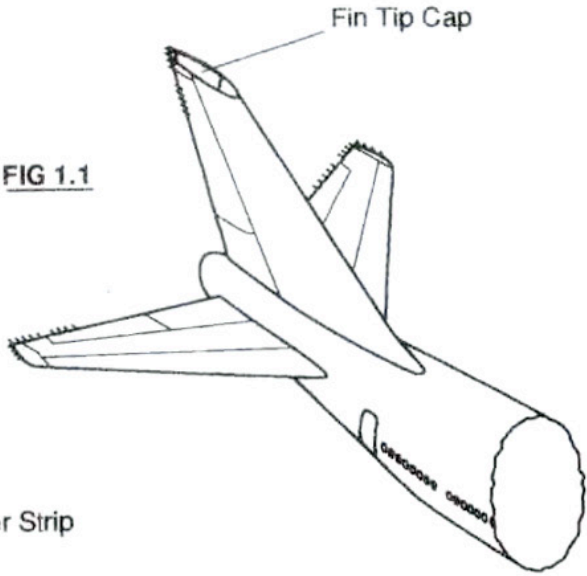
### **Recommendation**

In this case the lightning strike caused a false cowl overheat warning, loss of the anti-icing system on one engine, incorrect indication of engine oil temperature and loss of two of the three VOR systems on the aircraft, together with the dropping of fairly large pieces of the fin tip fairings on Sussex. The evidence indicated that the likelihood of the damage to the VOR systems and to the fin tip fairings could have been reduced by the modification described above. It has therefore been recommended that:

### **Recommendation 97-13:**

The CAA, in conjunction with the aircraft manufacturer, give detailed consideration to requiring the incorporation of Service Bulletin 747552027 on UK registered Boeing 747 aircraft. (Recommendation made March 1997).

**FIN TIP CAP**



G-BDXH FIN TIP

Diverter Strip

VOR/LOC Antennas

Fin Tip Cap Remains

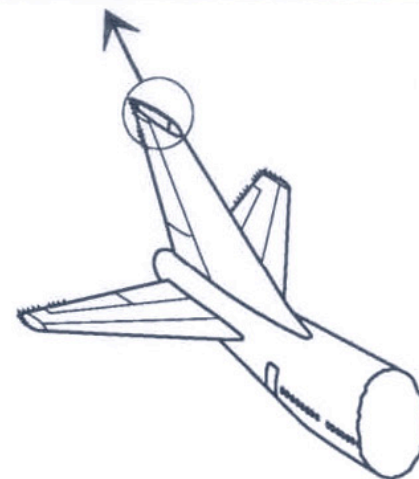
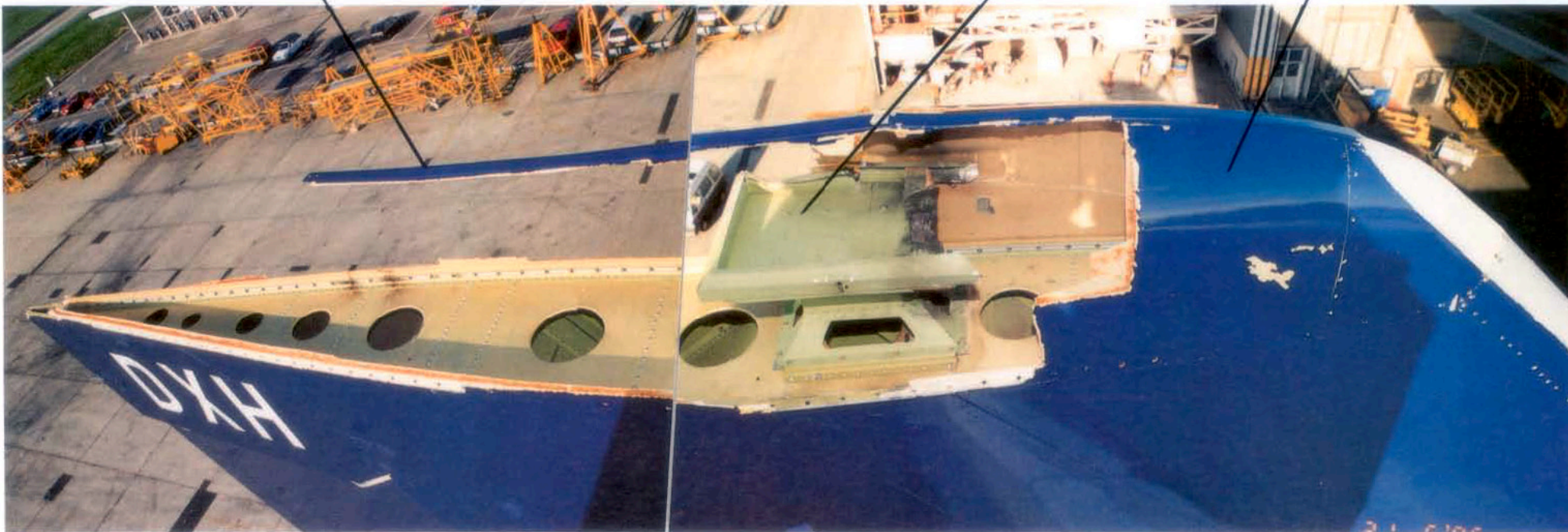


Fig 2