No: 11/88 **Ref: EW/C1061** **Category: 1a**

Aircraft Type and Registration:	Boeing 747-136, G-AWNA
No & Type of Engines:	4 Pratt and Whitney JT9D-7cn Turbofan Engines
Year of Manufacture:	1970
Date and Time (UTC):	28 February 1988 at 1206 hrs
Location:	Heathrow Airport, London
Type of Flight:	Scheduled passenger
Persons on Board:	Crew - 18 Passengers - 281
Injuries:	Crew - None Passengers - None
Nature of Damage:	Portion of No. 11 Krueger (leading edge) flap detached and further damage to flap and to leading edge of wing
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	42 years
Commander's Total Flying Experience:	10,597 hours (of which 3,421 were on type)
Information Source:	AAIB Field Investigation

The aircraft was being operated on a sector from runway 27R at Heathrow Airport to Dulles Airport, Washington DC. Shortly after take-off an unusual vibration was noticed, which the crew initially attributed to turbulence; it became more pronounced, however, and flap retraction was stopped at the Flap 1 position. The cabin crew advised the Captain that a section of leading-edge flap was projecting upwards on the left wing, just inboard of the No.2 engine. After jettisoning approximately 65,000 kg of fuel at FL80 the aircraft returned to London and, after completion of the "One Leading Edge Flap Inoperative" drill, a safe landing was made. The flight crew reported that no handling difficulties were experienced.

Another aircraft had reported debris on runway 27R and this runway was closed for approximately 10 minutes for the debris to be removed: it was found at about 8,500 feet along runway 27R and was later identified as the piece of flap missing from G-AWNA.

Examination of the aircraft showed that the gimbal fitting (figures 1 and 2) attached to the No.11 Krueger flap assembly had failed. The gimbal fitting consists of two splined gimbal end fittings (both present in figures) and top and bottom plates (only top plate present in figures 1 and 2): the bottom plate was missing and it was not found on any of the subsequent runway and taxiway sweeps. The mechanism which extends each Krueger flap. With the bottom plate missing, the ballscrew nut was

able to drop away from the failed gimbal fitting, allowing the No.11 Krueger flap to move upwards under the aerodynamic loads during the take-off. Scrape marks showed that the folding nose section of the flap had been forced against the No.2 engine pylon, resulting in a portion of the flap's nose section becoming detached.

As shown in figures 1 and 2, the failure had occurred around the radii of the lower lugs on the two gimbal end fittings and, additionally, there was one bolt missing (figure 2) between one of the end fittings and the top plate. The failure to find the missing bottom plate indicates that it had become detached prior to the accident flight, probably during flap extension on the previous sector.

Detailed metallurgical examination of the fracture surfaces was performed at the Royal Aerospace Establishment and revealed a small area of fatigue, shown in figure 1. Fatigue fracture in this Titanium material is characterized by an extremely small critical crack length. Although, in this particular instance, it is not apparent whether the fatigue failure or bolt failure occurred first, the manufacturer has attributed past failures of these fittings to looseness or fracture of the attachment bolts. Boeing Service Bulletin (SB) 747-27-2148, first issued in 1976, specified an increase of the torque on the 8 attachment bolts in each gimbal fitting and G-AWNA was modified in accordance with this SB.

The gimbal fitting was subsequently returned to the aircraft manufacturer in the USA. There it was confirmed that the fitting material was of the specified Titanium alloy and that the failure sequence was probably initiated by loosening or breakage of one or more of the bolts. On disassembly, all 3 of the remaining bolts were found to be correctly torqued; they were, however, also found to be extensively pitted and one bolt had a 0.016 inch crack emanating from a corrosion pit.

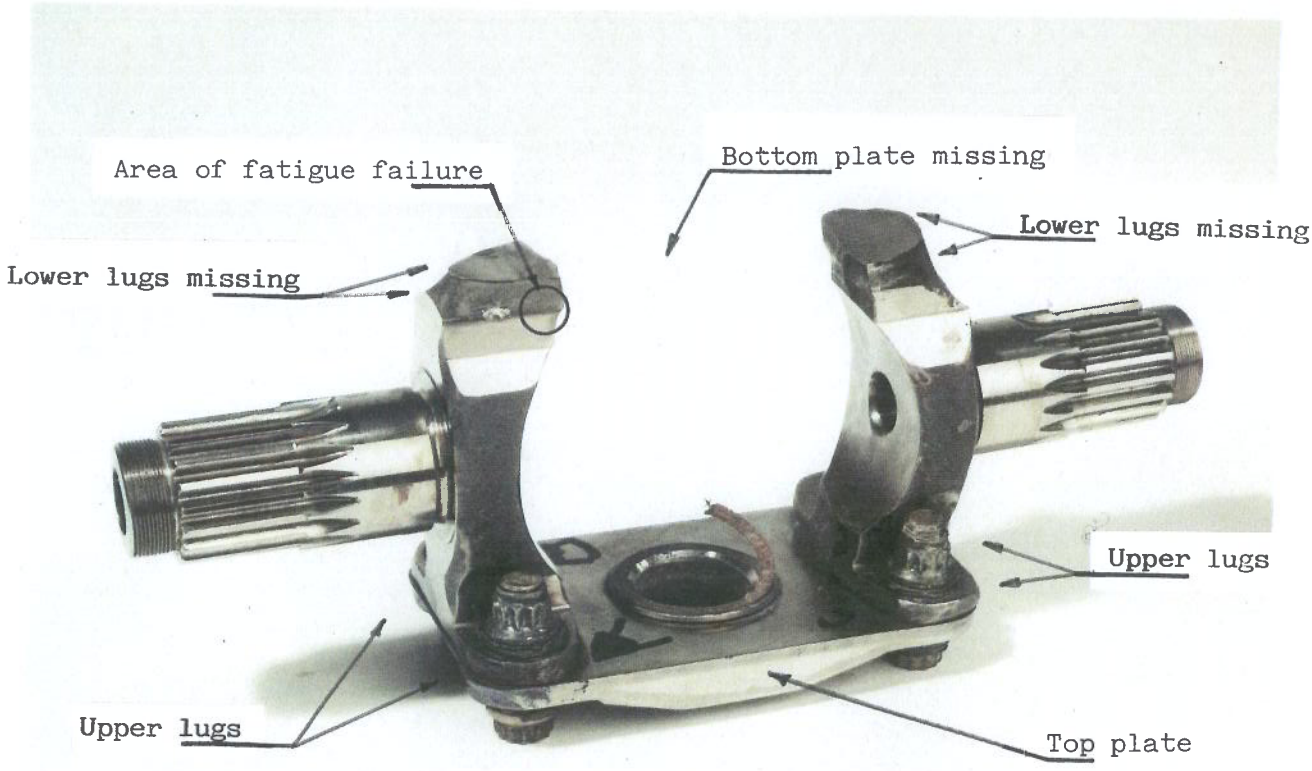
The bolt material was H11 steel which CAA Airworthiness Notice No.12, Appendix 35, reports as having an abnormally high failure rate, particularly in sress corrosion cases. The aircraft manufacturer has deleted the use of H11 bolts in production and H11 bolts are, in the case of the gimbal fittings, replaced by Inconel bolts on an attrition basis.

A Special Check of the gimbal fittings throughout the operator's fleet, performed after this accident, revealed that a number of bolts were at reduced torque and that some bolts were missing. The appropriate Service Bulletin (SB 747-27-2148) only calls for a one-time check, with no repetition; the operator, who maintains all the 747-100 series aircraft on the UK register, has, however, instituted the following:-

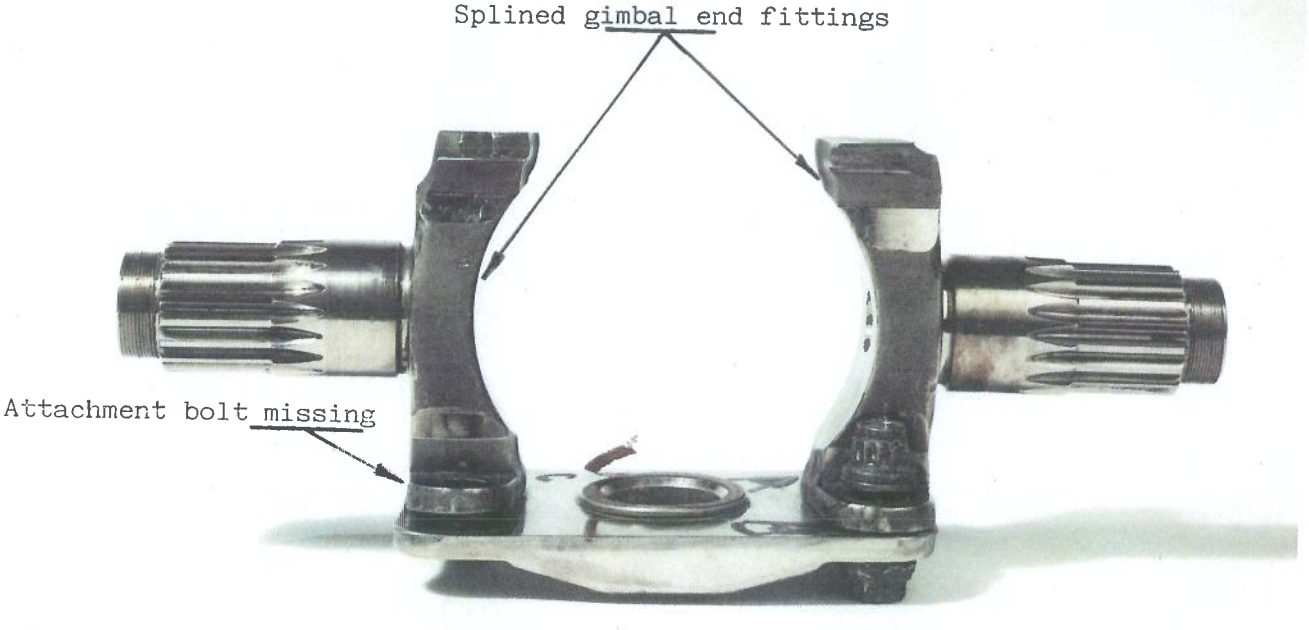
(1) replacement of all H11 gimbal attachment bolts with Inconel versions,

(2) changing of all gimbal assemblies which the Special Check identified as having operated with attachment bolt torque of less than 95 inch-lbs, and

(3) amendment of the maintenance schedule to include a torque check at Inter check frequency.



Gimbal fitting (G-AWNA)
- Figure 1



Gimbal fitting (G-AWNA)
- Figure 2