No: 8/92 **Ref: EW/A92/5/1** **Category: 1a**

Aircraft Type and Registration:	Boeing 747-212B, G-TKYO
No & Type of Engines:	4 Pratt and Whitney JT9D-7Q turbofan engines
Year of Manufacture:	1980
Date & Time (UTC):	25 May 1992 at 0425 hrs
Location:	On climbout from Narita International Airport, Japan
Type of Flight:	Public Transport
Persons on Board:	Crew - 21 Passengers - 245
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to left inboard flaps and wing trailing edge upper fixed panel
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	59 years
Commander's Flying Experience:	18,900 hours (of which 7,600 were on type)
Information Source:	AAIB Field Investigation

History of the flight

Flight VS 901 from Narita Airport, Tokyo, to London Heathrow was off-stand, on schedule, at 0355 hrs. Neither the Technical Log from the previous flight, nor the pre-flight checks for this flight, had revealed any significant technical abnormality and the take-off, from runway 34, was achieved without event.

The noise abatement procedure at Narita required that climb power was set at 1500 feet amsl, with the climb to the acceleration height of 3000 feet made at V_2 +10 kt (182 kt).

The initial climb was uneventful until, at 3000 feet/220 kt and as the flaps were retracted from 10° to 5°, a severe vibration was felt which appeared to emanate from the left side of the aircraft. The crew thought that a landing gear door had not seated properly and so, since the vibration ceased after about five seconds, the rest of the flap was retracted on schedule. However, when the aircraft then accelerated to a climb speed of 272 kt (V_2 +100 kt) the vibration returned, although to a lesser degree,

and the commander, believing that it was speed-related, reduced the speed by 10 kt. Although this caused the vibration to reduce, it could still be felt on the flight deck as a small, though rapid, horizontal circular movement of the floor.

The aircraft continued the climb to FL 290 and was above cloud with the 'Seatbelt' sign out, when a flight attendant came into the flight deck and said that the vibration in the area of door 3 left was very severe, and was alarming the passengers. The commander therefore asked the supernumary flight engineer to go into the cabin and make a visual inspection of the affected area, and the aircraft exterior. When he returned to the flight deck and reported that there was a significant 'hole' in the upper surface of the left wing, at the inboard trailing edge, the commander asked ATC for clearance to jettison fuel and return to Narita. He then accompanied the same engineer to inspect the damage for himself and was told that the size of the hole had already increased.

The flight engineer then positioned himself at door 3L so that he could observe the progress of the damage and, if necessary, report to the commander from that intercom station. The fuel jettison was successfully accomplished off the coastline to the southeast of Shoshi, at the minimum height of 6000 feet, and the aircraft returned to Narita. The commander had meanwhile consulted the Flight Manual, which required an increment of 5 kt to the V_{ref}, and decided to use 30° flap for the landing, which was subsequently accomplished without further event. However, by the time they had landed, the hole in the left wing had further increased in size.

Flight Recorders

The flight data recorder fitted was a Sundstrand digital flight data recorder (DFDR) which records 25 hours of data on a recycling 4 track magnetic metal tape. A replay was made using AAIB replay facilities. On two of the four tracks (tracks 1 and 3) the signal level was too low to allow transcription of any flight data, and on the remaining two tracks (2 and 4 which contained the accident flight) the data quality was poor.

The DFDR was returned to the overhaul agency for investigation. The unit failed the tests on tracks 1 and 3. The tape deck and the tape itself were found to be dirty. The deck was therefore stripped down, the tape was cleaned, relubricated and the recording heads cleaned. New bearings were fitted to the motor, the lower reel bearings were cleaned and relubricated, (the upper reel bearings being satisfactory) and a new motor belt fitted. The unit was reassembled and when tested data errors occurred on track 3. The tape was found to have 'flared' at the top edge. The recording heads were reworked due to slight uneveness and a new tape was fitted. Subsequent tests were satisfactory.

The unit had previously been fitted to G-VLAX from which it had been removed and a satisfactory readout obtained. Normal preventative maintenance was also carried out at that time. The unit was

fitted to G-TKYO on 3rd December 1991, and had therefore been on the aircraft for over 5 months. It had completed 2055 hours when the accident occurred. A routine readout from G-TKYO had not been carried out.

Replay of the DFDR for the accident flight confirmed the flap retration schedule which had been used by the crew, however the reported vibration was not evident from the flight recorder.

The cockpit voice recorder (CVR) was not replayed. The CVR contains a 30 minute recycling tape and therefore the relevant portion of the tape for this accident would have been overwritten.

Aircraft examination

The aircraft was examined prior to, and during, the repairs which were carried out at Narita airport. This revealed that damage had occurred to the top surfaces of the inboard fore and mid-flaps and that the whole trailing edge of the upper wing surface fixed panel, which abuts the fuselage fairing, had broken away (Figures 1 and 2), to leave a ragged and disbonded edge. At the outboard end, approximately the aftmost 60 inches of this panel were missing, together with a similar length of the aft portion of rib No 3, and approximately 20 inches of panel at the inboard end. The fractured surfaces of rib No 3 indicated that this had failed under overload conditions. The Configuration Deviation List for the aircraft allows for flight, subject to various limitations, with up to 112 x 36 inches of the aft portion of this panel missing, but makes no mention of possible damage to the flaps, or vibration. The upper surface of the fore-flap had been severely 'pounded' such that an area of its honeycomb structure towards the trailing edge, and several sections of upper skin, were missing. Similarly, crushing damage and a hole were present in the upper surface of the mid-flap. Upon considering the relative positions of the fixed panel trailing edge and this flap damage, it became apparent that the damage to the flaps had occurred as a result of the break-up of the panel's trailing edge whilst the flap had been in the range between 5° and fully retracted. Most of this damage was associated with the outboard half of the fixed panel. This panel is of composite construction with a honeycomb core and an examination showed no evidence of pre-existing delamination, disbonding or water contamination. No assessment of the detached sections could be made since these were not recovered.

The trailing edge of the fixed upper panel is designed so that it is deflected upwards, by a maximum amount of 1.75" at its trailing edge in line with the inboard rib, by the upper surface of the mid-flap at its inboard end when the flaps are fully retracted. It is intended that the outboard end of the upper panel should remain clear of the flaps. Rubbing strips and low friction paint are employed between these surfaces to minimise wear, the areas of contact being evident from witness marks on the paint. Wear patterns were apparent on the low friction paint of the affected area of the left fore-flap and, when compared with the right side of G-TKYO and several other aircraft examined, appeared abnormal in that a triangular shaped area of 'dirty' paint was coincident with the damage to the fore-flap. Close inspection of this area revealed it to have been caused by

the lower surface of the fixed panel 'hammering' the top surface of the flap as the panel trailing edge disintegrated.

A more significant area of witness marking was present on the fuselage side, in the region of the aft inboard edge of the fixed panel. At this location, marks from the rubber edge seal showed the extent to which the inboard aft edge of the panel had been flexed upwards, this marking being present on all other Boeing 747's examined. However, the extent to which the panel had been flexed upwards during normal operation was not conclusively established from these marks as some of the marking had undoubtedly resulted from the break-up of the panel. Nevertheless, the upper limit of the area of heavier witness marks suggested that this panel had been flexed in excess of the quoted maximum and certainly to a slightly higher level than panels on other aircraft, or that on the right side of the same aircraft. These witness marks are compared in Figures 3 and 4 with those from another aircraft.

Maintenance history

The fixed panel is mounted on three adjustable ribs, two of which incorporate a torsion bar spring, such that the height of the trailing edge may be set with reference to the wing. The procedure for rigging this panel, as set out in the Maintenance Manual for the aircraft, requires that a specific gap is maintained between the trailing edge and a 'straight edge' projected from the wing at the inner rib (No 1) position; that the trailing edge itself is flat within specified limits; and that a specific gap exists between the fore-flap and the fixed panel trailing edge at its aft outboard corner. In recent years, however, operators have experienced cracks, delamination and disbonding of this panel. In several cases such panels have broken up in flight, with resultant vibration and flap damage. A study by the manufacturer had revealed that there was an excessive pre-load condition between the inboard end of the inboard flap and the inboard end of the upper fixed panel on production aircraft. As a result, the manufacturer had issued revision No 747-129 to the Maintenance Manual on 12 September 1990, which was designed to reduce the initial pre-load displacement of the panel in this area, and Service Bulletin No SB 747 2261 on 7 March 1991. The Maintenance Manual revision increased the size of the reference gap at the No. 1 rib location and the Service Bulletin called for, in addition, a specific inspection of the panel for delamination, cracks and disbonding. It was required that an initial inspection be carried out within 600 flight-cycles after receipt of the Bulletin, with repetitive inspections at 1200 cycle intervals. However, as a result of continued reported problems with this panel, the manufacturer later amended this Service Bulletin, on 6 June 1991, to give revised figures for the reference gap, taking into account the disposition of fuel in the aircraft's tanks. Both the Maintenance Manual and Service Bulletin specify that the aircraft should be supported on its landing gear (ie not on jacks) during this check.
Figure 5 shows the left side panel, after the aircraft had been repaired, rigged in accordance with the revised Service Bulletin and flown back to London Heathrow, with the flaps in the fully retracted position. A measure of contact is evident between the inboard end of the fixed panel and fore-flap but little, if any, at its outboard end (as required). Figure 6 illustrates the rigging requirements.

The left upper fixed panel on G-TKYO was last inspected/rigged in December 1990 in accordance with the revised Maintenance Manual requirements, since when it had accumulated 678 flight-cycles and 6193 hours at the time of failure. Up to the time of the incident, the fixed panel had not been rigged in accordance with the revised Service Bulletin.

Additional information

During the course of this investigation another aircraft, a Boeing 747-283B, was also examined since the upper left fixed panel had been found damaged whilst the aircraft was undergoing a 'C' check. Upon removal, disbonding was found to have occurred between the lower skin and the honeycomb core over a distance of approximately 24 inches at the centre of the trailing edge of the panel and extending some 12 to 15 inches forward. The trailing edge within this region was reported to have been very 'flexible'. No abnormal wear patterns were apparent on the upper flap surfaces on this aircraft but, on repair, water contamination was found within the panel in this area. This aircraft had accumulated 680 flight cycles and 4219 hours since the panel was last inspected/re-rigged on 5 June 1991.

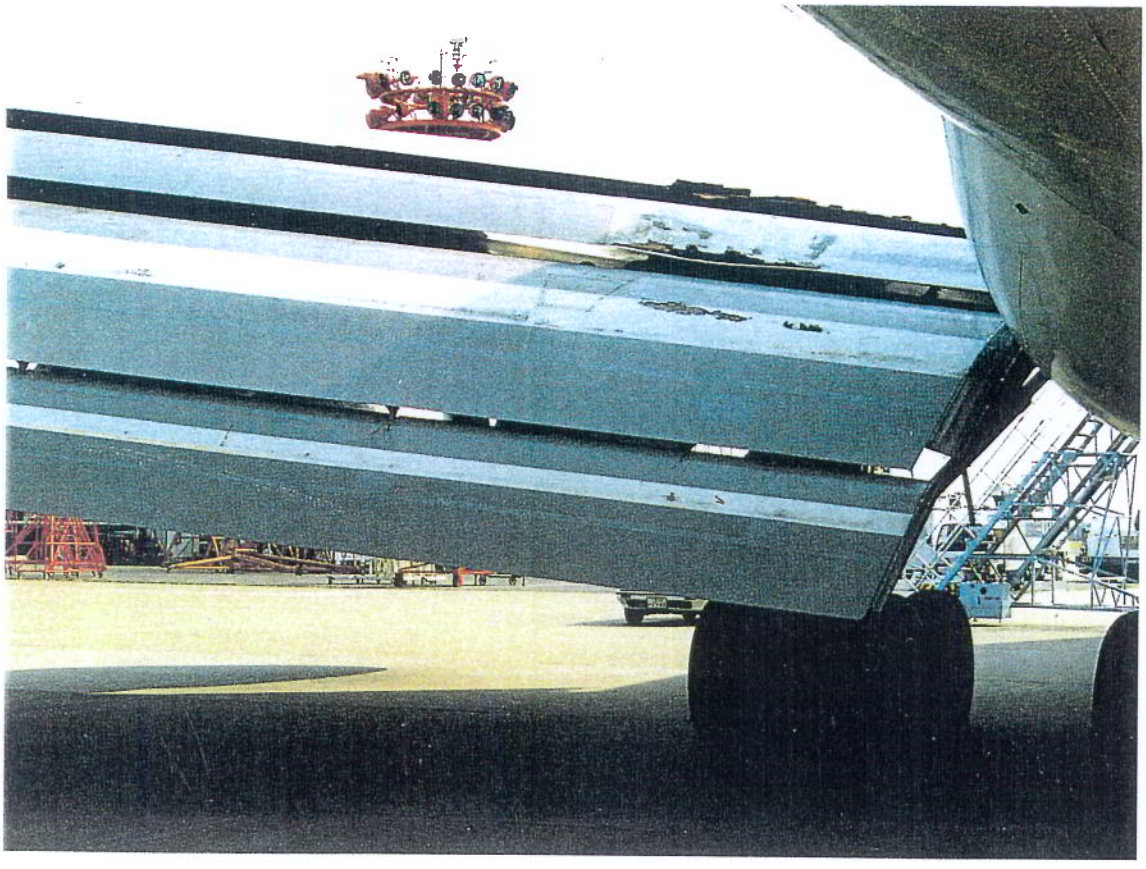
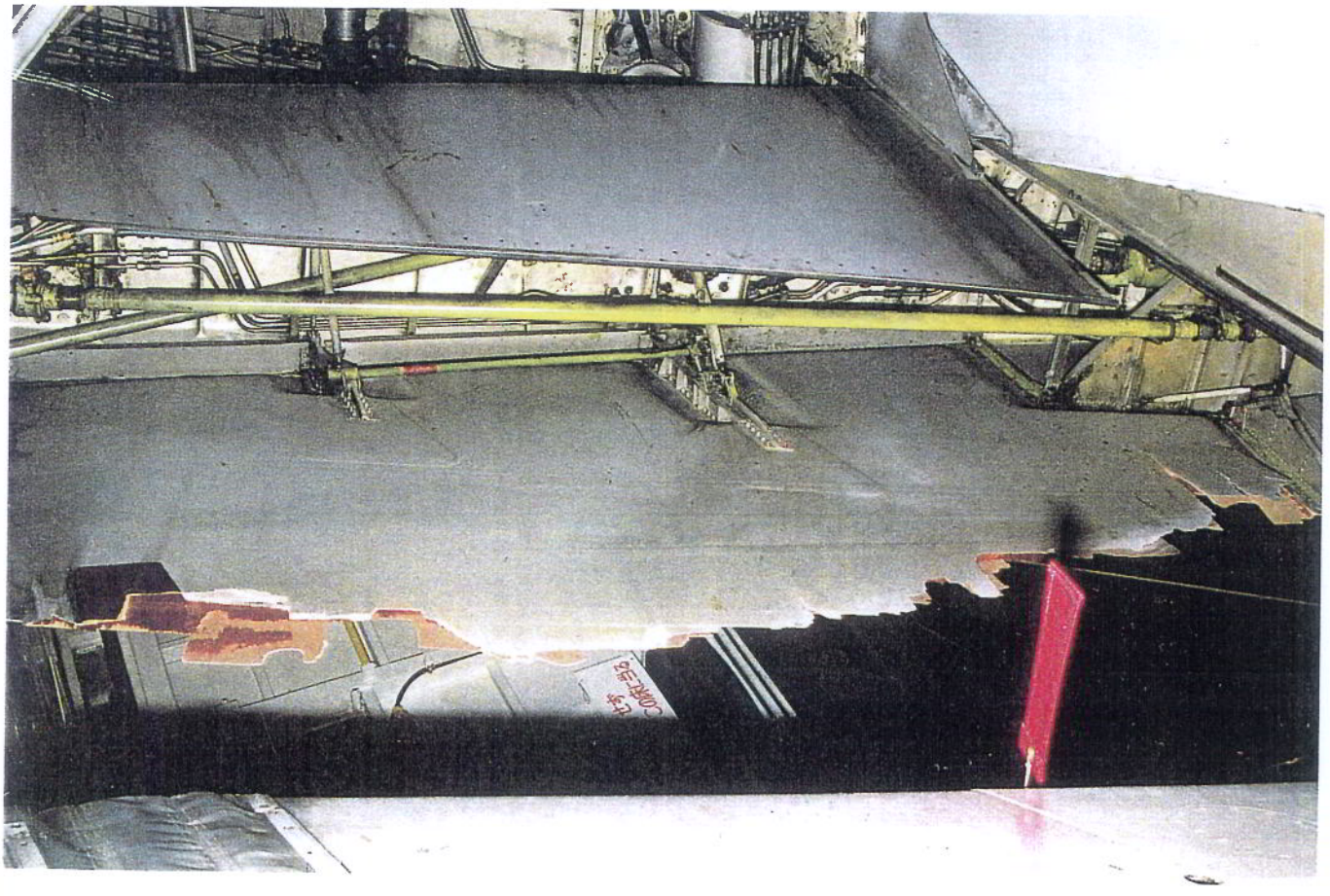


Figure 1

General view of flap damage



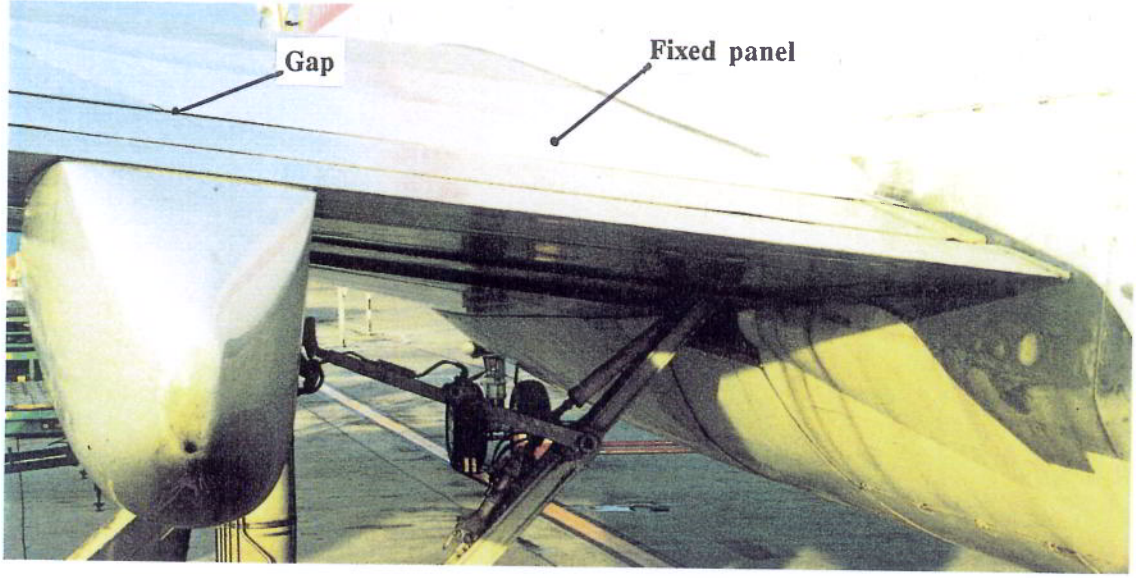
Lower view of damage to fixed upper panel

Figure 2

Comparison of fixed panel witness marks against fuselage side

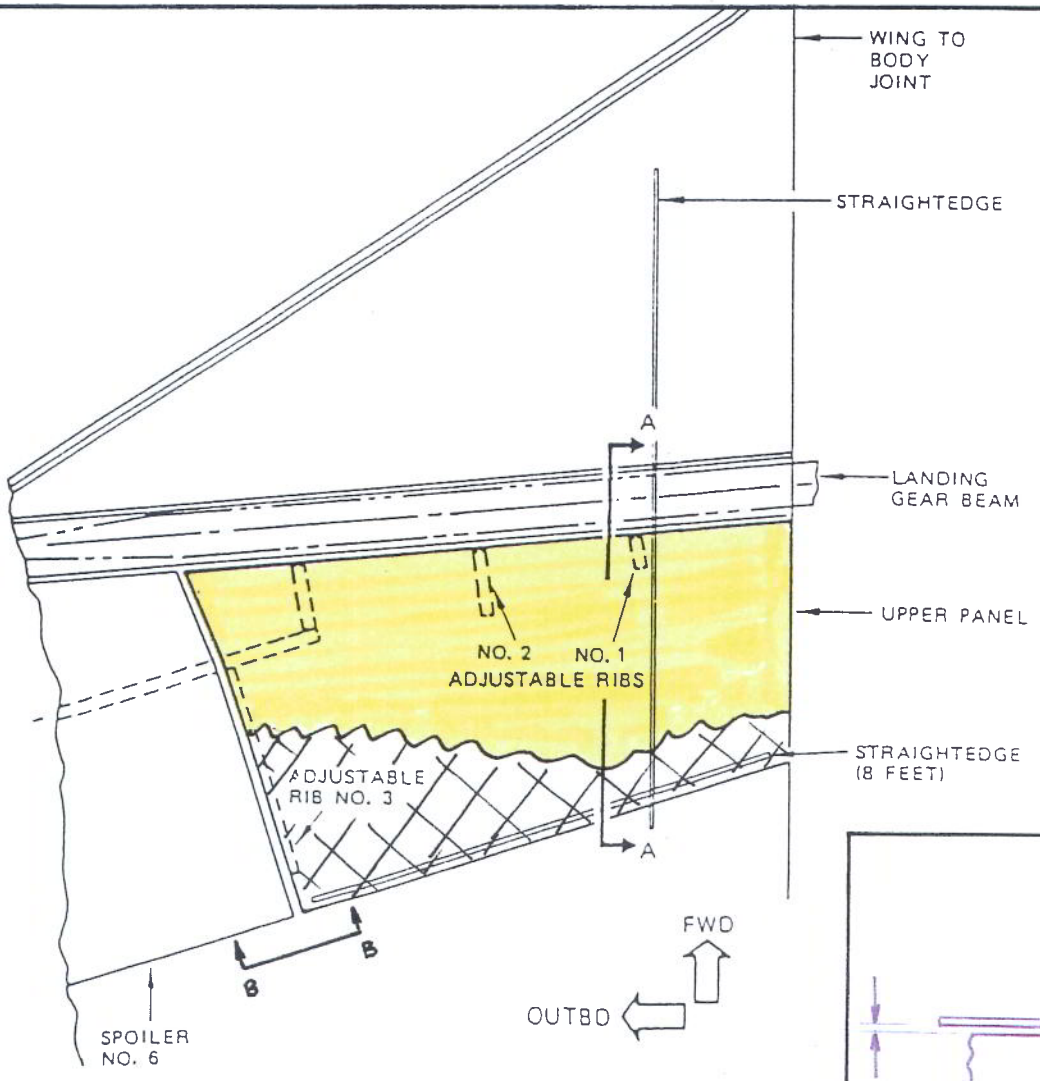
Figure 3

Figure 4

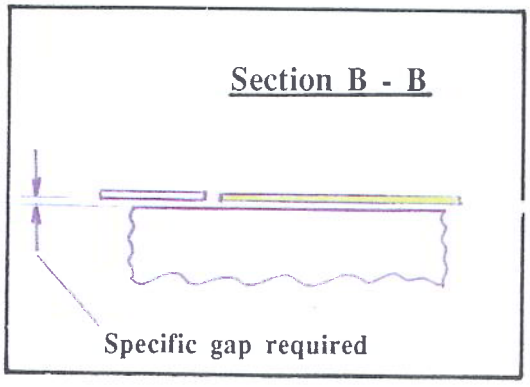


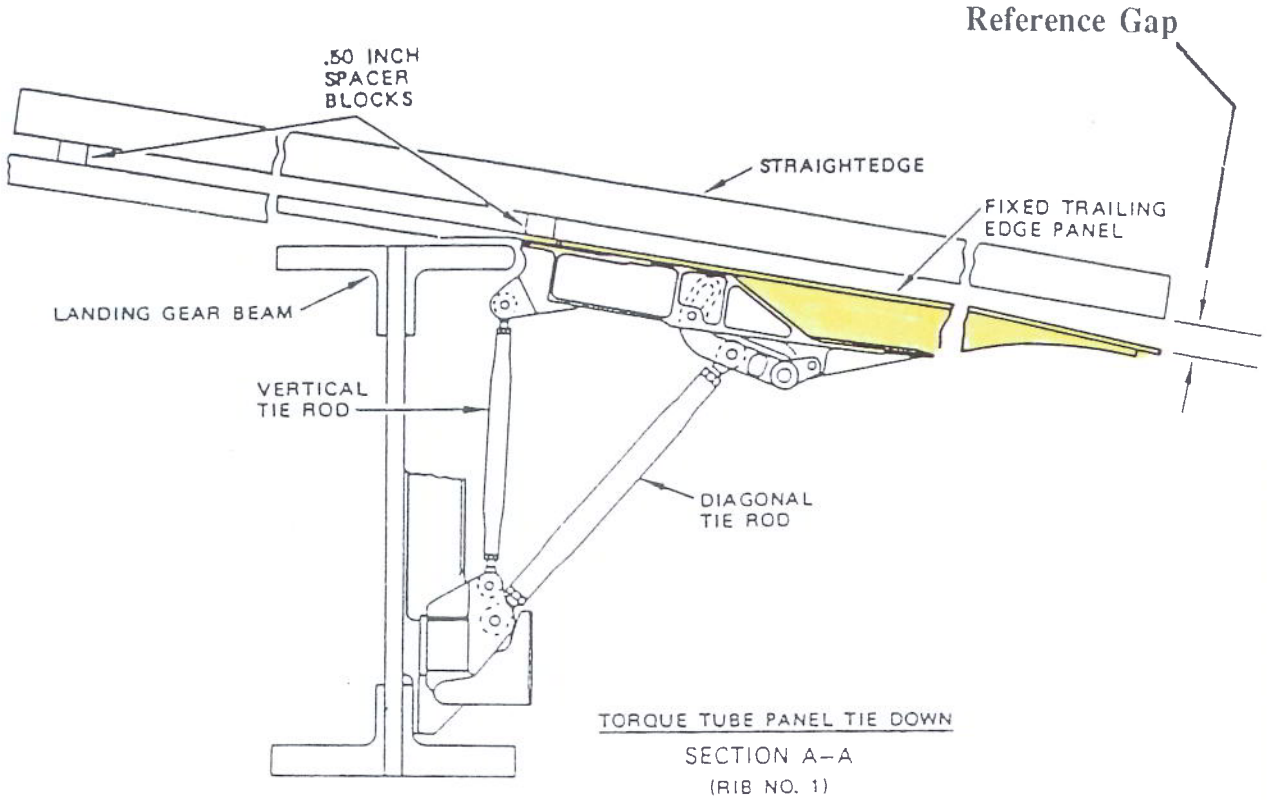
Flaps fully in, after repair/re-rig

Figure 5



Fixed Trailing Edge Upper Panel Adjustment





TORQUE TUBE PANEL TIE DOWN
SECTION A–A
(RIB NO. 1)

Figure 6