Serious Incident

Aircraft Type and Registration:	Boeing 747-433, G-UNET
No & Type of Engines:	4 Pratt & Whitney PW4056-3 turbofan engines
Year of Manufacture:	1991 (Serial no: 25075)
Date & Time (UTC):	6 January 2024 at 1800 hrs
Location:	London Heathrow Airport
Type of Flight:	Commercial Air Transport (Cargo)
Persons on Board:	Crew - 4 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Left upper wing panel detached
Commander's Licence:	N/A
Commander's Age:	N/A
Commander's Flying Experience:	N/A
Information Source:	Enquiries by the AAIB

Synopsis

After landing, an upper left wing panel detached from the aircraft and came to rest in the grass area to the side of the runway. The panel was found two months later and the AAIB was notified. The wing panel most likely detached due to fatigue cracking of its supporting rib. This rib was known to suffer from cracks and the aircraft manufacturer had published a Service Letter with actions to help mitigate cracking, although the actions have not always prevented it. Analysis by the aircraft manufacturer indicated that there was low probability of a detached wing panel causing damage that would result in either an injury or prevent continued safe flight. The main hazard was considered to be runway foreign object debris (FOD) which could cause damage to a landing or departing aircraft.

History of the flight

On 7 March 2024 the AAIB received a report from the operator of Heathrow Airport that a large metal panel had been found in the grass area to the south of Runway 27L, about 600 m west of the runway threshold (Figure 1). The panel was sent to the AAIB for examination where it was identified as an upper wing panel from a Boeing 747 aircraft. Subsequent enquiries revealed that a Boeing 747 cargo aircraft (G-UNET) had arrived on stand at Heathrow Airport two months earlier, on 6 January 2024, with this panel missing from its left wing. The flight crew had been unaware that a panel had detached from the aircraft, but it was identified as missing during the subsequent turnaround. The aircraft operator had filed a Mandatory Occurrence Report to the CAA but did not report it to the AAIB as they had not considered it to meet the threshold for an accident or serious incident[1].

Footnote

[1] The operator stated that this was because Boeing SL 747-SL-57-101-B (discussed later in the report) stated that the separation of such a panel was not considered safety-related.

Figure 1

Location of metal panel (circled in red) relative to Runway 27

Examination of the panel

The panel (Figure 2) had maximum dimensions of 1.1 m by 0.9 m. It was identified as having detached from the upper left wing, adjacent to the outboard edge of spoiler 5 (Figure 3). The panel had a structural failure at its forward edge, revealing the internal honeycomb, and a structural failure at its inboard rib. The outboard edge of the panel had detached from a line of rivets. The rib along the inboard edge exhibited evidence of previous repairs.

The panel part number was identified as 65B11629 and the rib part number as 65B10865.

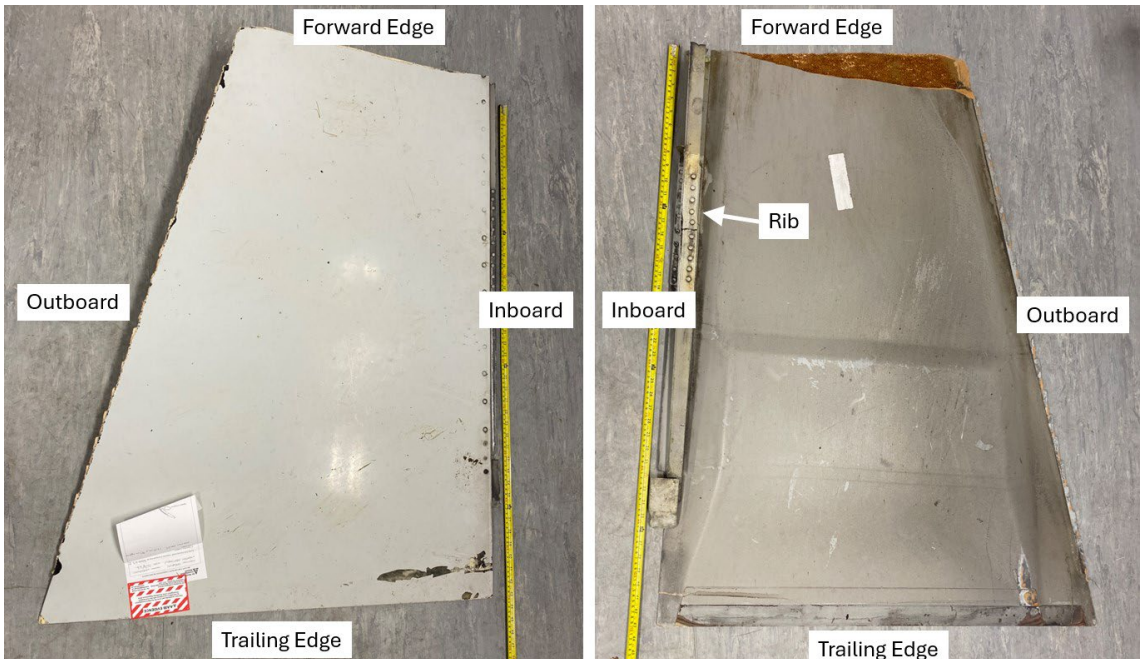

Figure 2

Photos of detached wing panel

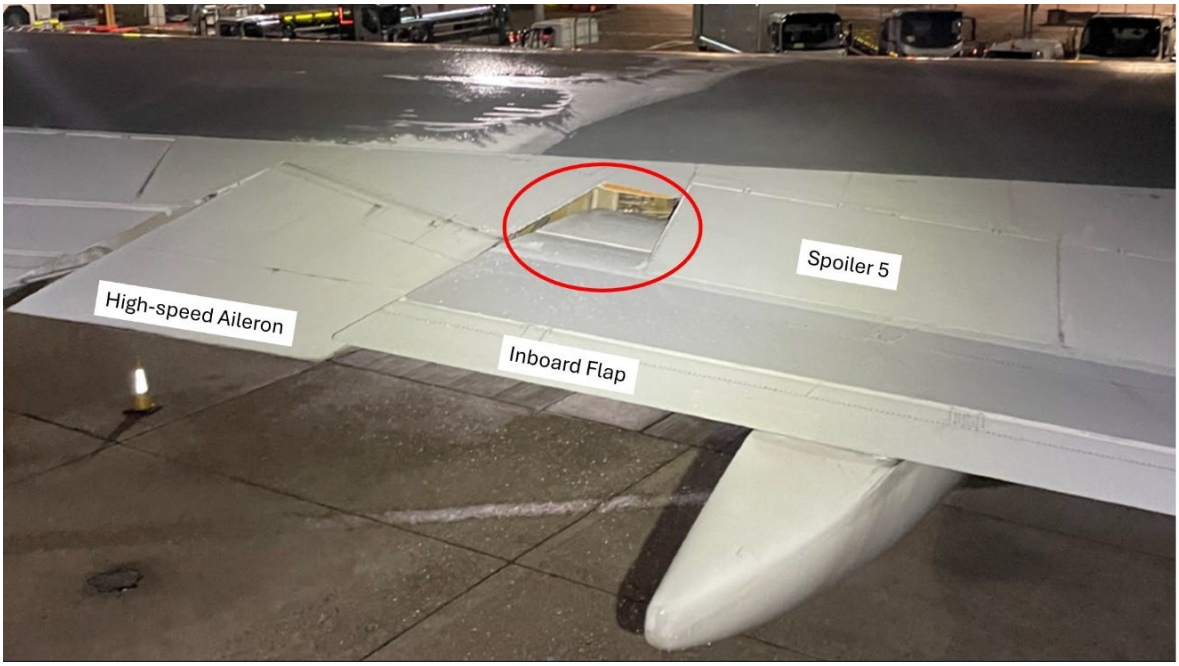

Figure 3
Location of missing wing panel (circled in red)

Service Letter to address wing panel detachments

On 30 November 2010 the aircraft manufacturer published Service Letter (SL) 747-SL-57-101-B 'Fixed Trailing Edge – Spoiler Support Revision at WBL 255.692 and WBL 432.6504'. It stated that:

> *'Operators have reported cracks in the reference e) P/N 65B11544 fixed trailing edge rib located at WBL255.69, and at the reference f) P/N 65B10865 fixed trailing edge rib located at WBL432.65. Cracks typically originate from the rib lower chord just aft of the diagonal tie rod fitting and propagate upwards through the web as shown in the attached illustration. Continued crack growth can cause complete fracture of the rib. In cases of complete rib fracture the reference g) upper fixed TE panel common to the rib at WBL432.65 can also become damaged.*
>
> *Some operators have reported in-flight departure of a portion of the reference g) panel and reference f) rib.*
>
> *Damage to the ribs and panel, including the partial departure of the panel during flight, is not considered safety-related and does not significantly affect the controllability of the airplane. No regulatory action is anticipated regarding this issue.'*

The illustration from the SL is shown in Figure 4 with the crack location on G-UNET superimposed in red.

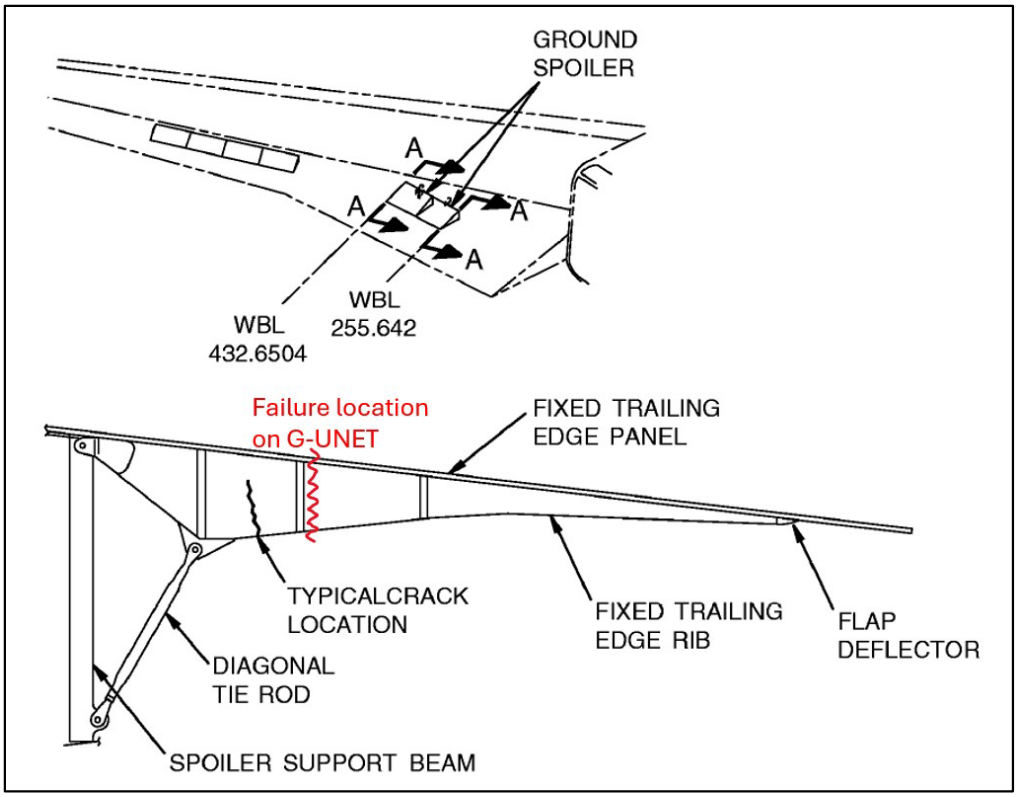

Figure 4

Illustration from Service Letter 747-SL-57-101-B with location of rib failure on G-UNET shown in red.
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The SL explains the following cause:

> *'For improved aerodynamic performance the 747-400 wing was designed to flex more than the 747-Classic wing. Greater wing flex of the 747-400 increases the upward movement of the TE flap which may in turn impose higher than expected loads to the reference e) and f) ribs. The magnitude of upward loads imposed by the flap is sensitive to adjustment of the ribs relative to the flap. Investigation of cracked ribs submitted to Boeing by operators show indications of fatigue cracking due to cyclical upward loads acting on the rib over an extended period of time.*
>
> *The original release of this service letter discussed the implementation of spoiler downrigging for improved range performance. To address the spoiler support rib cracking issue, Boeing recommended operators determine if an airplane had downrigged spoilers, and if so, to check that that the spoilers were correctly adjusted. However, additional operator reports indicate that airplanes with correctly adjusted spoilers may still develop spoiler support rib cracks. The current revision to this service letter therefore discusses the fixed TE panel rigging change. Spoiler downrig is still accomplished, if applicable, when performing the Suggested Operator Action.'*

The suggested operator action specified in the SL is to adjust the spoiler support rib clearance between the fixed trailing edge (TE) upper panels and the upper surface of the inboard TE flap as specified in the SL. The SL was originally issued in 2005 but at that time it did not include information about parts departing the aircraft.

Aircraft operator action

The aircraft operator stated that it was not aware of any specific task having been carried out on G-UNET concerning SL 747-SL-57-101-B. Following the left wing panel failure, the operator tasked their maintenance organization to check the spoiler support rib clearances on G-UNET's right wing against SL 747-SL-57-101-B; they were found to be within limits with no adjustments required. They also stated that the rib that failed would have been inspected during wing zonal inspections which are carried out during A-checks at 1,000 flight hour intervals.

Information from the aircraft manufacturer

The aircraft manufacturer was asked for information on previous wing panel detachments. They were able to find the following information on ten panels of the same part number that had detached:

- 8 panel detachments were found during walkaround inspections after landing with no detail as to the phase of flight.
- 1 was listed as 'panel departed on approach'. This panel detachment was spotted by the control tower during approach.
- 1 was during departure. The crew felt a shudder on departure and noted missing wing material during the flight.

The manufacturer's database search also included an entry where this panel was found cracked during a D-check.

The aircraft manufacturer provided details of an analysis of the effects of a fixed trailing edge upper wing panel departing the aircraft. They had considered the following four failure modes:

Potential for the fixed trailing edge upper wing panel to:

1. Depart and impact the aircraft such that the damage results in loss of continued safe flight and/or landing.
2. Depart and penetrate the fuselage such that the damage results in injury to an occupant or aircraft depressurisation.
3. Depart the aircraft and impact a person on the ground.
4. Depart the aircraft and create runway FOD (foreign object debris).

The potential for loss of continued safe flight and/or landing, and the potential for an occupant injury or depressurisation, were both assessed by the aircraft manufacturer '*not to be a safety concern*'. The risk to a person on the ground was, based on the manufacturer's service history studies, also assessed as '*not to be a safety concern'*.

The most likely hazard from a separated wing panel was considered to be runway FOD, which could damage another aircraft. However, the aircraft manufacturer considered that the FOD hazard was '*not to be a safety concern*' as it is mitigated by existing airport initiatives intended to control and minimise exposure to runway FOD, and by aircraft design standards which address protection from damage caused by runway FOD.

The aircraft manufacturer was asked if they had data on the number of airports equipped with automatic FOD radar detection systems. They stated that data from an FAA briefing in 2018 indicated that 21 airports worldwide had such FOD detection systems installed, of which 19 were capable of taking a Boeing 747. They expected that the number of airports with such systems has increased over the past six years.

Foreign object detection at Heathrow Airport

Heathrow Airport was equipped with a FOD radar detection system. The airport operator stated that the system was sensitive enough to detect small objects the size of a screw or part of a bird carcass, so it would have easily detected a part the size of the detached wing panel. However, the system only scans the hard surfaces of the runways, so it would not have detected the wing panel in the grass area to the side of the runway. The airport was also equipped with Surface Movement Radar designed to track aircraft, but this was not sufficiently sensitive to detect a part the size of the wing panel.

The wing panel had detached from the aircraft on 6 January and was found two months later, on 7 March. The airport operator stated that because it was winter the grass was mown less frequently, otherwise the part would have been found sooner.

Analysis

The left wing panel was found 600 m beyond the threshold for Runway 27L indicating that it probably detached from the aircraft after touchdown when the spoilers were deployed. The panel most likely cracked and then failed at its supporting rib first, before failing at the leading edge honeycomb structure. The aircraft manufacturer's Service Letter 747-SL-57-101-B indicated that this rib was known to suffer from fatigue cracks and failures, and recommended mitigating action involving adjusting spoiler support rib clearances. There was no documentary evidence that the actions in the SL had been carried out on the incident aircraft; however, when the opposite right wing was checked the clearances were within the limits of the SL.

The aircraft manufacturer's analysis indicated that the loss of such a wing panel in-flight had an acceptably low probability of causing damage that would result in either an injury or continued safe flight.

The most likely hazard from a separated wing panel was considered to be runway FOD, which could cause damage to a landing or departing aircraft. It was runway FOD that caused the catastrophic accident to Concorde (F-BTSC) during takeoff from Charles de Gaulle Airport in July 2000[2]. Heathrow Airport had a FOD radar detection system that would have detected the wing panel had it ended up on the runway surface. However, not all major airports worldwide are equipped with FOD radar detection systems. Mitigation therefore relies on runway inspections and aircraft design standards which address protection from damage caused by runway FOD.

Conclusion

The left wing panel detached from the aircraft after touchdown, most likely due to fatigue cracking of its supporting rib. This rib was known to suffer from cracks and the aircraft manufacturer had published a Service Letter with actions to help mitigate it, although the actions did not always prevent it. Analysis by the aircraft manufacturer indicated that there was low probability of a detached wing panel causing damage that would result in either an injury or prevent continued safe flight. The main hazard was considered to be runway FOD which could cause damage to a landing or departing aircraft. FOD radar detection systems are an effective mitigation, but not all major airports are equipped with them.

Footnote

[2] https://bea.aero/uploads/tx_elydbrapports/f-sc000725a.pdf [accessed 15 July 2024].