Tail strike on rotation, Boeing 777-200B, N784UA

Micro-summary: **This Boeing 777-200B experienced a tail strike on rotation.**

Event Date: **1999-11-05 at 1308 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 777-200B, N784UA

AAIB Bulletin No: 5/2000 Ref: EW/C99/11/1 Category: 1.1

Aircraft Type and Registration:	Boeing 777-200B, N784UA
No & Type of Engines:	2 Pratt & Whitney PW 4090 turbofan engines
Year of Manufacture:	1997
Date & Time (UTC):	5 November 1999 at 1308 hrs
Location:	London Heathrow Airport
Type of Flight:	Public Transport
Persons on Board:	Crew 18 - Passengers - 256
Injuries:	Crew None - Passengers - None
Nature of Damage:	Abrasions to lower tail surface
Commanders Licence:	Airline Transport Pilots Licence
Commander's Age:	55 years
Commander's Flying Experience:	18,567 hours (of which 408 were on type)
	Last 90 days 236 hours
	Last 28 days - 91 hours
Information Source:	AAIB Field Investigation

History of the flight

The aircraft was scheduled to fly from London Heathrow to Los Angeles. Whilst taxiing for Runway 27 Right (27R) the crew completed the briefing and entered the payload weights into the Flight Management Computer (FMC). During the taxi to the holding point the crew was given a change to the weights and these were entered correctly in the FMC. V speeds were entered in accordance with the company procedures as V1: 154 kt, VR: 161 kt and V2: 167 kt. The aircraft was following a Gulf Air aircraft which was cleared to line up and was passed a surface wind of 180°/15 kt with infrequent gusts of 28 kt.

Following the departure of one aircraft ahead the Boeing 777 was cleared for take off. With checks completed the commander lined up the aircraft and with the first officer handling the controls a

rolling take off was commenced. Left bank control input and right rudder were required to maintain the runway centreline and some crosswind yaw was experienced but it was not considered to be significant. Acceleration was normal and approaching V1 of 154 kt there was an 8 to 10 kt reduction in airspeed which steadily restored to its previous value, and rotation was initiated at 161 kt. All three crew members considered that the rate and angle of rotation was normal, and the aircraft was accelerated towards V2 of 167 kt. The crew then received an Engine Indication and Crew Alerting System (EICAS) message that the aircraft had suffered a tail strike.

The aircraft was depressurised in accordance with the emergency checklist and climbed initially to FL 90 and then held at Daventry at FL 70 where 130,000 lb of fuel was jettisoned to reduce weight for landing at Heathrow. The emergency checklist was completed and the aircraft was given radar vectors for Runway 27L at Heathrow where an uneventful landing was carried out.

Aircraft examination

The aircraft was examined at the operator's maintenance facility at Heathrow. There were signs of runway contact on the underside of the fuselage from about Station 2130 to Stn 2274; a total length of some 3.65 metres (12 feet). At Stn. 2150 (pressure bulkhead) and at most of the frames as far back as Stn. 2268 the outer skin had been completely abraded away on the fuselage centreline. The tail strike sensor at Stn. 4041 had been abraded away by about 50%.

Flight recorders

Recorded information was available from the FDR and Quick Access Recorder (QAR) fitted to the aircraft. The 30 minute CVR had continued to run after the aircraft had been parked on its stand following the accident flight and it had recorded over the pertinent events. The recording from the QAR was sent to the operator for replay where it passed into their Flight Operations Quality Assurance (FOQA) programme and was subsequently not made available to the investigation. An AAIB Inspector replayed the FDR and it was from that source alone that the following data was obtained.

The recorded data showed that, during the latter stages of the take-off roll, the handling pilot held between 15° and 20° of anti-clockwise control wheel together with right rudder. At that stage all the left side spoiler panels were deployed to between 4.5° and 7°. Just prior to rotation, the differences between airspeed and ground speed indicated a headwind component fluctuating between 10 kt and 2 kt. At the onset of rotation, with airspeed increasing through 159 kt, the control column was moved rearwards, initially to 45% of full travel from neutral, and then slightly forwards to 35% of full travel; more anti-clockwise control wheel was applied with an associated increase in left spoiler panel deflection. As the aircraft pitched up through 7.7° with a pitch rate of at least 3.5°/second, a maximum anti-clockwise control wheel input of 52° was recorded. There was also a reduction in derived headwind component from 4 kt to 1 kt. Although individual spoiler panel deflections were not recorded at exactly the same time as the peak anti-clockwise control wheel movement, due to differing sample rates of the parameters, a maximum deflection for Panel 6 of 21.7° was recorded 0.4 seconds later, when the control wheel was at 41.2° anti-clockwise.

After the aircraft pitch attitude had increased through 10.7° and with the main landing gear still not tilted, the control column was moved rearwards to 22% of its travel and the control wheel was briefly centralised. A minimum headwind component of 0.25 kt was derived from data recorded at this time. The maximum aircraft pitch attitude recorded with main gear not tilted was 12.8° and it is likely that it was at this time that the tail contacted the runway; roll attitude at that point was

recorded as between 0.5° and 1.5° left wing down. Status of the tail strike sensor, although indicated on the flight deck, was not a parameter recorded on the FDR. Pitch rate was recorded with a period between samples of 2 seconds. Just after the aircraft left the ground and the main landing gear tilted, pitch attitude temporarily reduced to 11.3° before increasing to 15° as the aircraft climbed away.

A comparison was made between the accident take off and four previous take offs recorded on the FDR where the aircraft configuration was similar. It was apparent that the magnitude and rate of application of aft control column during the accident rotation was significantly higher and resulted in a pitch up rate of at least 3.5°/second compared with 2.5°/second for the previous take offs. The pitch rate was well established before the small reduction in headwind component occurred. During rotation the effect on pitching moment of asymmetric spoiler deployment was considered by the aircraft manufacturer and was judged negligible.

It was noted during the investigation that there was an anomaly in the FDR recording of aircraft pitch attitude on the FDR. Pitch attitude was read, at 200 milli-second intervals, alternately into two data buffers prior to transmission to the FDR at four times per second. However, only one of the two data buffers was being read with the result that every three out of eight values of pitch attitude recorded in the FDR were repeated. This was confirmed as a design error in the programming of the flight data acquisition function of the aircraft. A change to the recording system has been developed and will be included in the 'Block 2001' update to the Aircraft Integrated Monitoring System (AIMS) which is scheduled to occur fleet-wide in the 4th quarter of 2001. All references to pitch attitude in this report have been corrected to allow for the anomaly.

Discussion

The operator's expanded normal operating procedures state that: 'At VR rotate smoothly using a continuous rate of approximately 2.5° per second to establish an initial pitch attitude of approximately 15°. In gusty or windshear conditions, consider delaying rotation and increasing initial climb out speed. Early, rapid, or excessive rotation may cause aft fuselage contact with the runway. With the main gear on the runway, tail contact occurs at approximately 11°.'

Whilst the manufacturer concluded that the effect of asymmetric spoiler deployment on pitching moment was negligible, a drop in headwind component had a more significant effect. This delayed the main landing gear leaving the runway, such that, if the rate of rotation was not checked, there was an increased risk of a tail strike. On this occasion the pitch rate and nose up attitude were recorded as 3.5°/second and 12.8° respectively with the main gear still on the runway and this exceeded the normal operating procedure limits.