Uncommanded roll, Boeing 737-236, G-BKYI

Micro-summary: **This Boeing 737-236 experienced uncommanded roll coincident with flap selection.**

Event Date: **1996-11-08 at 0820 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 737-236, G-BKYI

AAIB Bulletin No: 1/98 Ref: EW/C96/11/3 Category: 1.1

Aircraft Type and Registration:	Boeing 737-236, G-BKYI
No & Type of Engines:	2 Pratt & Whitney JT8D-15A turbofan engines
Year of Manufacture:	1984
Date & Time (UTC):	8 November 1996 at 0820 hrs
Location:	Approach to Runway 27L
	London Heathrow Airport
Type of Flight:	Public Transport
Persons on Board:	Crew - 6 - Passengers - 82
Injuries:	Crew - None - Passengers - None
Nature of Damage:	None
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	45 years
Commander's Flying Experience:	Approximately 12,000 hours (of which 5,000 were on type)
	Last 90 days - 110 hours
	Last 28 days - 50 hours
Information Source:	AAIB Field Investigation

History of the flight

The aircraft was inbound to London Heathrow on a scheduled flight from Jersey. While fully established on the approach for Runway 27L, the aircraft encountered two separate uncommanded roll events. The first was with flap 5° selected, followed by a more pronounced event almost coincident with the flap 25° selection. In both cases the aircraft rolled in a gentle but positive manner. The crew considered that the roll force was very smooth and quite strong, with no detected rudder or yaw damper movement. The crew commented that the rolling motion was not characteristic of any previously experienced wake vortex encounters.

The commander, who was the handling pilot, initiated a go-around and transmitted a PAN call to ATC advising of a flight control problem. The possibility of a flap asymmetry was considered, but there was no indication of such an asymmetry on the flap indicator. A handling check was performed by decelerating the aircraft to an approach/manoeuvring speed of 150 kt with 15° flap. No abnormalities were noted by the crew, so radar vectoring was accepted for a left hand pattern to reposition for a further ILS approach whilst maintaining the established 15° flap landing configuration. The autopilot was engaged after the go-around and maintained until about 700 feet on final approach, followed by an uneventful manual landing by the First Officer.

The London Heathrow METAR for 0820 hrs gave the surface wind as 170°/2 kt, visibility 18 km, few/scattered cloud base 6,000 feet. The temperature was +3.6°C and dew point +1.5°C, the QNH was 1023 mb.

Engineering Investigation

The aircraft was withdrawn from service and subjected to a detailed programme of checks carried out by the operators' maintenance personnel in conjunction with the manufacturer and AAIB.
The manufacturer initially drew attention to the possibility of the lost motion clutch system of the inboard flap drive (intended to break out if a new flap setting is selected with the flap slot/tracks obstructed) having permitted asymmetric inboard flap deployment to occur. No evidence was found to suggest that this had occurred and it was noted that the flap deployment sequence (ie the relationship between linear and angular movement) made it unlikely that asymmetry of the inboard flaps, occurring at the stage in the deployment sequence coincident with the uncommanded roll events, could produce a major rolling moment.

The operators' engineering department required the following list of work to be carried out on the aircraft:

Inboard trailing edge flap adjustment/test.

Outboard trailing edge flap adjustment/test.

Spoiler adjustment/test.

Aileron trim control adjustment/test.

Replacement of rudder PCU.

Cycle of yaw damper switch and observation of rudder for signs of deflection.

Inspection and leak check of forward toilet system.

Investigation of water leak from FWD galley (found on initial inspections).

Replacement and bench testing of aileron clutch mechanisms.

Inspection of inboard mid-flap for correct rigging.

Check of flap fairing with flaps up.

Check of aileron rigging and tensions.

Hydraulic fluid sample analysis.

The only discrepancies found on completion of these checks were:

(i) Water leak located in forward galley area.

(ii) Flap clutch mechanisms failed bench break-out test.

(iii) Water leak into junction box 5 found.

(iv) Yaw damper coupler failed BITE test 7 (coupler replaced).

The break-out forces of both flap clutch mechanisms were only slightly below specification and comparable to some other units which had seen a similar period of service. Junction box 5 contains wiring associated with stabilator trim control function; defects in this area will not, in isolation, influence roll or yaw behaviour.

The aircraft was subsequently test-flown without any significant defect being noted. It was returned to service and thereafter revealed no evidence of any associated defect.

Flight Data Recorder Information

The Quick Access Recorder (QAR) was replayed by the operator; the data showed that at 2,700 feet, 182 kt on approach the aircraft rolled 8° left wing down at a rate of about 5°/sec. This was opposed by the pilot with almost 40° control wheel input, before the aircraft returned to wings level. Ten seconds after the uncommanded roll the flap was selected and moved from 5° to 10° and the aircraft continued the approach. At 1,400 feet, 155 kt, with flap 20° and landing gear down,the aircraft underwent two roll reversals, initially to 10° left and then 10° right, with a maximum roll rate of about 6°/sec. This occurred 3 seconds before flap 25° was selected. The roll reversals were opposed by opposite control wheel inputs. The engine power was then increased as the go-around was initiated, flap 10° was selected and the minimum altitude was 1,000 feet before the aircraft began to climb away. The subsequent approach was normal.

In response to the incident, after analysis and consideration of the circumstances, the manufacturer stated that:

'The first event has the characteristics of a typical wake vortex turbulence encounter with perturbations in airspeed and normal acceleration which are inconsistent with pitch attitude and thrust. The second event shows airspeed perturbations, however, the small changes in normal load factor are consistent with changes in pitch attitude. In addition to the airspeed changes, the perturbations in lateral acceleration and the character of the roll suggest that the event was also an external disturbance. Similar perturbations in lateral acceleration occur during wake turbulence encounters when the vortex core impinges on the vertical tail... The FDR data showed that for both the events the aircraft started rolling before significant heading changes occurred. The absence of heading changes during the start of the events indicates that the roll did not result from sideslip (e.g. sideslip due to rudder deflection).'

Wake Vortex Consideration

In order to establish the possibility of a wake vortex encounter, the sequence and spacing of several preceding aircraft was determined from radar information. The approach sequence studied was a Boeing 747, Boeing 767, Boeing 737 400, DHC Dash Eight followed by 'YI, the incident aircraft.

Figure 1 shows the approach path of the incident aircraft and the DHC Dash Eight. The first un commanded roll event occurred at 8.1 nm from touchdown, when 'YI was 2.9 nm behind the Dash Eight (60 seconds elapsed time). The second uncommanded roll event occurred at 4.5 nm from touchdown when 'YI was 2.8 nm behind the Dash Eight (56 seconds elapsed time).

The Dash Eight wake would have been affected by the tendency of its wake to descend and also by wind drift. Wake vortex studies suggest that the vortices tend to drift slowly downwards at a rate of approximately 400 feet per minute. This aspect was detailed in AAIB Bulletin 2/97 Reference EW/C96/9/3.

In Figure 1, the position of the wake is therefore represented by a band, and the figure shows that the path of 'YI was coincident with the estimated location of the wake at around the altitude of the recorded uncommanded roll events.

Reduced Final Approach Spacing Trial at Heathrow Airport

A trial is in progress at London's Heathrow and Gatwick Airports to reduce the final approach spacing of aircraft to a minimum of 2.5 nm, provided that certain criteria are met. Details of these criteria were published by the CAA in a Yellow Aeronautical Information Circular (AIC) 94/1997 (Yellow 264) published on 15 July 1997. Phase 2 (the current phase) of this trial commenced in January 1996.

The salient features of the trial are that both aircraft should be within 15 nm and greater than 4 nm from touchdown, established on an ILS Localiser (or on a closing heading to it) and that no Wake Vortex Spacing minima is detailed in the Wake Vortex Table accompanying the AIC. In this case, the Dash Eight was categorised as a 'Small' and the B737 as a 'Lower Medium' for Wake Vortex separation purposes (Note: the MATS Part 1 Inbound Wake Vortex requirements are modified at Heathrow by splitting the Wake Vortex Group categorisation of 'Medium' into 'Upper Medium' and 'Lower Medium', based upon Maximum Allowable Take-off Weight.). For the Reduced Final Approach Spacing Trial, the AIC indicates that Wake Vortex separation is not required, thus allowing reduced separation to 2.5 nm until 4 nm from touchdown. In the Manual of Air Traffic Services Part 1, the required spacing between successive aircraft on final approach for these groups is 3 nm minimum.

The upper winds recorded by the preceding Boeing 737-400 aircraft on approach were:

2,500 feet 252°T/6 kt

2,000 feet 278°T/4 kt

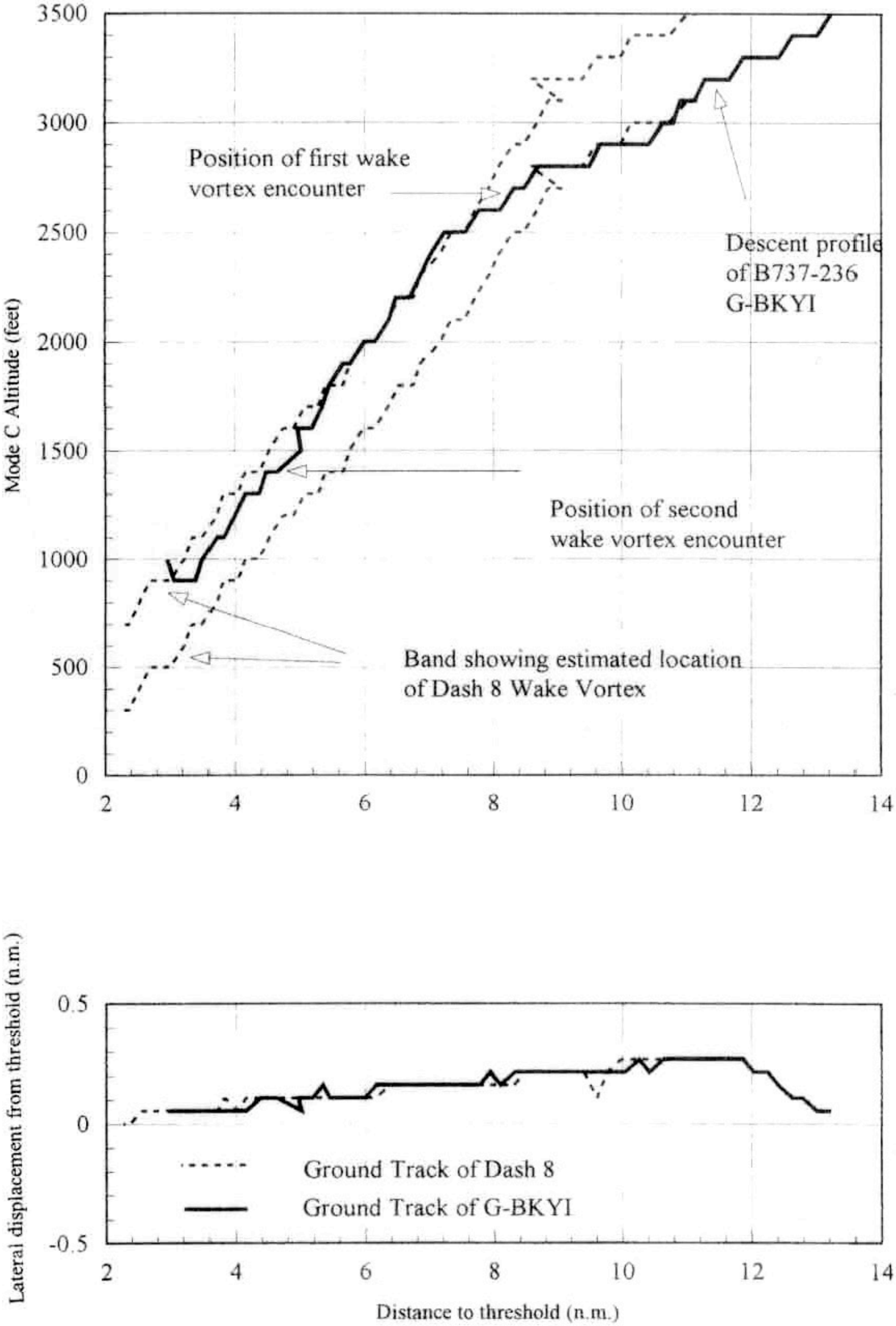
1,500 feet 280°T/6 kt

1,000 feet 251°T/6 kt

Touchdown 157°T/4 kt

An objective of the Reduced Separation Trial is to maintain a high landing rate in conditions of strong headwinds so that tactical capacity is not adversely affected. The minimum recommended headwind component stated in the trial conditions was 10 kt. On this occasion, therefore, the trial was not in operation and the minimum radar separation requirement should have been 3 nm.

Figure 1


3500
3000
2500
2000
1500
1000
500
0
2
4
6
8
10
12
14
Mode C Altitude (feet)
Position of first wake vortex encounter
Descent profile of B737-236 G-BKYI
Position of second wake vortex encounter
Band showing estimated location of Dash 8 Wake Vortex
0.5
0
-0.5
Lateral displacement from threshold (n.m.)
Ground Track of Dash 8
Ground Track of G-BKYI
Distance to threshold (n.m.)