Boeing 747-400, 9M-MPC

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Aircraft Type and Registration:	Boeing 747-400, 9M-MPC
No & Type of Engines:	4 Pratt & Whitney 4056 turbofan engines
Year of Manufacture:	1992
Date & Time (UTC):	5 April 1998 at 0957 hrs
Location:	Runway 27L, London Heathrow Airport
Type of Flight:	Public Transport
Persons on Board:	Crew - 22 - Passengers - 314
Injuries:	Crew - None - Passengers - None
Nature of Damage:	Damage to rear fuselage frames, APU access doors andboth inboard elevators
Commander's Licence:	Airline Transport Pilot's Licence (Malaysia)
Commander's Age:	57 years
Commander's Flying Experience:	14,200 hours (of which 1,896 were on type)
	Last 90 days - 119 hours
	Last 28 days - 53 hours
Information Source:	AAIB Field Investigation

History of the flight

The aircraft was departing from Runway 27L on a scheduled passenger flight to Kuala Lumpur. The flight crew consisted of an operating captain (the commander) and a first officer who was experienced as a 'cruise pilot' on the type but was relatively inexperienced as a handling pilot for take off and landing on line operations. A second captain and first officer were occupying the supernumerary seats on the flight deck.

Normal pre-flight procedures were carried out and, as the first officer was to be the handling pilot, the commander gave him a take-off briefing which paid special attention to the correct rotation technique and transition to the initial climb. For noise abatement reasons full take-off thrust was to be used and the aircraft flown at a speed of about V_2+10 kt until passing the flap retraction altitude. This technique was used to minimise noise in the vicinity of the Noise Monitoring Terminals (NMT) located close to the Standard Instrument Departure routes around the airport. The requirement is that the aircraft should pass the NMT at not less than 1,000 feet above aerodrome level, then should maintain a climb gradient of at least 4% (243 feet/nm) until passing an altitude of 4,000 feet.

The aircraft's take-off weight was 372,304 kg and the maximum permitted take-off weight (structural limit) was 394,625 kg. There was 143,500 kg of fuel on board for take off, giving a fuel endurance of 13.3 hours for a planned flight time of 11.9 hours. Take-off speeds were correctly calculated for the ambient conditions using a flap setting of 20°, being a V_1 of 153 kt, V_R of 168 kt and V_2 of 177 kt.

The crew recorded the pre-departure weather as a surface wind from 200°M at 19 kt, temperature +10°C and a mean sea level pressure of 992 mb, with a dry runway state. With the surface wind conditions, the crew calculated that the aircraft would have a 6 kt headwind component and an 18 kt crosswind component for take off. The aircraft's Operations Manual indicated that the maximum permitted crosswind component for take off from a dry runway was 30 kt (with gusting to 35 kt). Company procedures permitted first officers to be handling pilot for take off (subject to commander's discretion) with crosswind components up to 20 kt.

The Tower controller passed the surface wind as 210°M at 15 kt as take-off clearance was issued. The take off commenced at 0957 hrs. During the take-off acceleration, the commander noted that the airspeed indication (speed tape and trend vector arrow displays on the Electronic Attitude Director Indicator) was fluctuating at around 100 kt and at V_1. The rotation was commenced at V_R, but the commander perceived that the speed increased towards V_2+20 kt as the rotation continued. In order to assist the first officer in achieving the correct speed for the initial climb, the commander made an additional rearward control column input. This caused the aircraft to pitch up at an increased rate and the tail of the aircraft struck the runway as the aircraft left the ground. This was felt in the rear cabin and two of the four occupants on the flight deck were also aware of the contact with the runway. The stick shaker activated momentarily and a forward control column input was made to reduce the pitch attitude. The aircraft continued to climb away, with the first officer adjusting the pitch attitude to the correct climb attitude. The landing gear was not retracted until the flight path had stabilised and the aircraft was passing about 1,000 feet agl. ATC informed the aircraft that some debris had been observed falling from the tail section.

An APU Fire Warning then occurred and the APU fire action was carried out (the APU had been shut down after engine start and was not in operation for take off). This was followed up by reference to the Quick Reference Handbook (QRH) procedures for APU Fire and Tail Strike on

Takeoff. The aircraft was depressurised in accordance with the requirements of the Tail Strike procedure and the commander decided to jettison fuel before returning to land at Heathrow. Despite previous discharge of the APU fire extinguisher, an APU Fire Warning continued to occur intermittently throughout the remainder of the flight. The commander considered that this warning was spurious, probably brought about the damage to the tail section of the aircraft.

The cabin crew were informed of the situation and it was decided to position crew members at the rear of the aircraft cabin in order that they may report any abnormal symptoms.

The aircraft climbed to FL100 under radar control and was geographically positioned in an area so that it could dump fuel. The aircraft dumped 74,000 kg of fuel then returned to London Heathrow for an uneventful landing on Runway 27R at 1057 hrs with the commander as handling pilot. The actual landing weight was 283,400 kg, which was some 2,300 kg below the maximum landing weight limit.

After landing, the crew contacted the attending Airport Fire Service (AFS) by VHF link on 121.6 MHz. The AFS confirmed that there was no smoke or fire visible on the aircraft, so it taxied onto a parking stand (R34) close to the landing runway. The passengers were deplaned normally.

Examination of the aircraft

The damage to the underside of the rear fuselage started almost 20 feet aft of the rear pressure bulkhead and extended from three frames forward of the APU bay (Frame No. 2598), to Frame No 2764 near the extreme aft tip of the fuselage structure. Apart from the frames having been buckled, severe abrasion damage had occurred to the fuselage skin on the centreline. The forward APU firewall (Frame No 2658) was found to be buckled and cracked; the rear firewall (Frame No 2742) was also buckled. Access to the APU bay was via two doors, joined along the centre line and hinged at their upper edges. The left side door, which was found at Wraysbury, some 3 miles from Heathrow, had sheared off at its hinge. Most of the right door had been torn off below the hinge line, and was subsequently found on farmland near Byfleet, approximately 13 miles after take off. The APU itself had not sustained any damage in the incident and there had been no fire.

Examination of the doors showed that the contact with the runway had caused the latching mechanism to become disengaged, with the result that both doors would have been allowed to rotate outwards and upwards. There were light contact marks on the fuselage skin above the APU bay, together with two symmetrically disposed punctures on either side. In addition, there had been heavy impacts of the doors onto the undersides of both elevators, which were of composite

construction. There were a number of punctures in the skin of the elevators, which had penetrated to the upper surfaces in several places.

The APU bay was equipped with a fire detection loop that was attached to the doors for part of its length. This had broken when the doors departed from the aircraft, with the result that two cables had trailed aft out of the left side of the APU bay, and flailed against the side of the fuselage. The bare cable ends had chipped the paint off a localised area such that electrical shorting could have occurred. This may have been responsible for the intermittent APU fire indications on the flight deck. Damage to the aircraft can be seen in the photographs at Figure 1.

Heathrow Automatic Terminal Information Service (ATIS) and Wind Information

ATIS information code 'Kilo' was broadcast from 0908 hrs until 0931 hrs. This indicated a surface wind of 200° at 15 kt, variable between 160° and 230°. This was used by the crew for take-off performance planning purposes.

Updated information code 'Lima' was broadcast from 0931 hrs to 0957 hrs. This indicated a surface wind of 200° at 16 kt, variable between 160° and 230°.

Further updated information code 'Mike' was broadcast from 0957 hrs (9M-MPC's take-off time), indicating a surface wind of 200° at 16 kt, minimum 11 kt, maximum 26 kt, variable between 170° and 230° with the present weather being a rain shower.

All three broadcast recordings contained the information that *'turbulence may be experienced during the last mile of final approach to Runway 27R.'*

The wind data for the ATIS broadcast is copied from the METAR observation (or Special observation) taken at intervals by the Met Office at the airport. The wind speed and direction data is derived from an anemometer located at the south west corner of the airport. An additional anemometer is located at the north east corner of the airport. Anemograph recordings were available for these two sites. At the time of the accident, these showed a variation in direction from 200° to 230° at the south west anemometer and from 170° to 250° for the north east anemometer. The wind speed variations were between 9 and 24 kt at the south west anemometer and between 12 and 24 kt at the north east anemometer.

Additionally, ATC is equipped with automated displays of surface wind data from four anemometers located at each end of each of the two parallel runways. The controllers have wind data for both ends of the runway simultaneously displayed for the respective departure and landing runways. These displays show the mean wind speed and direction averaged over the previous two minutes. Any variation in wind direction over the last 10 minutes is displayed if the variation has been more than 60° during that ten minute period. Any variation in wind speed is displayed if it has been greater than 10 kt above or below the current 2 minute mean speed. Wind information passed by controllers to the aircraft is based upon these displays and associated criteria. The information displayed is not recorded.

The three aircraft preceding 9M-MPC for take off were passed wind information of 220°/12 kt, 210°/15 kt, and 210°/12 kt at 0951 hrs, 0952 hrs and 0953 hrs respectively. At 1057 hrs, the time of 9M-MPC's landing back at Heathrow, the surface wind was from 210°M at 19 kt.

Effect of the World Cargo Centre on wind velocity over Runway 27L

Prior to the construction of the World Cargo Centre building to the south of Runway 27L at Heathrow, wind tunnel testing was carried out to evaluate the effects of the presence of the building on the wind velocity over Runway 27L. For the ambient wind conditions at the time of this accident, the measured effect of the presence of the building was to produce a slight decrease of about 2 kt in wind speed (crosswind and headwind components) at a position some 1,700 metres from the start of the take-off run for Runway 27L. At around 1,800 metres from the start, there was then an increase in the wind speeds, some 2 kt headwind and 4 kt crosswind component.

It is not considered that these changes alone would have produced a significant effect on the take-off handling or performance in this case.

Digital Flight Data Recorder (DFDR) and Manufacturer's Information

The initial investigation at Heathrow caused the aircraft loading to be checked manually with each container being weighed accurately in order to validate the weight and centre of gravity calculations used in determining the take-off speeds and trim setting. The actual aircraft loading was found to agree closely with that shown on the load sheet prepared for the flight.

The manufacturer was provided with a copy of the DFDR data from 9M-MPC (Figure 2). The manufacturer compared this with original data from the validation and certification test programme

which closely the matched the weight and balance conditions of 9M-MPC. The test take off achieved an average rotation pitch rate of 2°/sec, using some 2° less elevator input than was achieved on 9M-MPC.

From analysis of the DFDR data, 9M-MPC's response to the control inputs was found to be correct, the stall warning stick shaker system activated at the correct warning threshold and the elevator take-off trim setting was correct for the conditions indicated on the load sheet.

The manufacturer's Flight Crew Training Manual for the Boeing 747-400 series states:

> 'For optimum take off and initial climb performance, initiate a smooth continuous rotation at VR to the target pitch attitude. Rotate smoothly at an average pitch rate of 2 to 3 degrees/second. A 10 degree body attitude is achieved in approximately 3 to 5 seconds (all engines) and 5 to 6 seconds (3 engines) with lift off occurring at a pitch attitude of 8.5 to 10 degrees.'

> 'Aft fuselage contact occurs at 12.5 degrees pitch attitude with wheels on the runway and landing gear struts extended.'

The actual pitch rate achieved in this case was 3.6°/sec initially, which then increased to about 5.5°/sec during the additional rearward movement of the control column. The tail-strike occurred at a pitch attitude of 12.5° nose up. The indicated airspeed data showed abnormal fluctuations during rotation, including a 16 kt increase over one second to V_2, followed by an 11 kt decrease. Based on the motion of the aircraft following lift off, there appeared to be some local atmospheric disturbance (windshear or gusts) which could have lead to the fluctuation in airspeed indication.

The presence of rain shower activity in the vicinity of the airport at the take-off time could have produced transient wind shear effects and local wind gusts.