Boeing 747-236B, G-BDXJ

AAIB Bulletin No: 10/2000 Ref: EW/G2000/05/16 Category: 1.1

Aircraft Type and Registration:	Boeing 747-236B, G-BDXJ
No & Type of Engines:	4 Rolls-Royce RB211-524D4 turbofan engines
Year of Manufacture:	1980
Date & Time (UTC):	15 May 2000 at 0800 hrs
Location:	London Heathrow Airport
Type of Flight:	Public Transport
Persons on Board:	Crew - 18 - Passengers - 336
Injuries:	Crew - None - Passengers - None
Nature of Damage:	Keel beam damage behind wing and No. 3 engine pylon damage
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	50 years
Commander's Flying Experience:	13,387 hours (of which 3,382 were on type) Last 90 days - 136 hours Last 28 days - 38 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and follow up with the operator

Synopsis

During an automatic landing the aircraft nose pitched down just prior to touchdown causing the aircraft to land heavily. The aircraft experienced minor airframe damage but there were no injuries to the passengers or crew.

History of the flight

The aircraft was operating a scheduled return flight from Miami to London Heathrow Airport. The weather conditions on arrival at Heathrow were dry with light winds and good visibility. The crew were carrying out an automatic landing on Runway 27L for practice purposes. The aircraft was configured during the approach for an automatic landing with all three autopilots engaged. (The

three autopilots are designated 'A', 'B' and 'C' channels for identification purposes). At 1,000 feet radio height the 'A' channel autopilot disengaged itself, but the approach was continued as the aircraft retains full automatic landing capability with two autopilot channels engaged. The approach down to the flare was satisfactory and the automatic flare manoeuvre was correctly initiated by the autopilot at 50 feet radio height, when the control column moved backwards to raise the nose of the aircraft and slow the rate of descent before touchdown. At about 30 feet radio height however, the control column moved forward unexpectedly and the aircraft began to pitch nose down. The pilot rapidly intervened by disengaging the autopilot and pulling back sharply on the control column, but there was insufficient time to arrest the high rate of descent which had developed and the aircraft landed very firmly. There were no injuries to passengers or crew, but the aircraft sustained minor airframe damage.

Autopilot operation

To perform an automatic landing on the Boeing 747-236, the Navigation Mode switch on the Autopilot/Flight Director Mode Selector Panel is selected to the 'LAND' position. The 'A', 'B' and 'C' channel autopilot engage switches are then selected to the 'COMMAND' position. The first autopilot channel to be selected ('first in command') immediately performs Part 1 of a self-test routine (called a confidence check) and if it passes, engages its hydraulic control actuators to take over pitch and roll control of the aircraft. In normal operation, one autopilot channel is already engaged on the approach, in which case Part 1 of the confidence check occurs when 'LAND' is selected. The other two autopilot channels, although also selected to 'COMMAND', will only engage their hydraulic control actuators if these channels pass Parts 1 and 2 of the confidence checks, which are automatically initiated at 1,000 feet radio height. Concurrent with this, Part 2 of the confidence check is also performed on the channel 'first in command'. If any of the three autopilot channels should fail the confidence checks, the affected channel will disengage and the corresponding autopilot engage switch will jump to the 'OFF' position. This explains why the 'A' channel autopilot disengaged at 1,000 feet during the approach. Loss of one autopilot channel during a triple autopilot approach will not adversely affect the aircraft's ability to perform an automatic landing, as the autopilot system is designed to land the aircraft fully automatically on two autopilot channels. The third channel therefore provides a level of redundancy so that the approach can be continued should one of the three autopilot channels disengage. During an automatic landing approach the output commands of the three channels are continuously compared and the mid value of the three output commands is used to control the aircraft.

Once the glide slope and localiser signals have been captured on the landing approach, the source of the autopilot actuator control commands switches over automatically at 1,000 feet radio height from the autopilot pitch and roll computers to the Landing Control Logic Units (LCLUs). The LCLUs provide automatic approach and landing control including the automatic flare function and rely on accurate radio height and rate of change of radio height data in order to achieve this. The crew is given a visual indication that the flare manoeuvre has been correctly initiated at 50 feet radio height by the 'FLARE' indicator light on the Flight Mode Annunciator panel changing from white to green.

Quick access recorder data analysis

The aircraft was fitted with a Quick Access Recorder (QAR) which records many different aircraft parameters such as aircraft height and speed at frequent intervals and stores them on an optical disk which can be easily removed from the aircraft and quickly analysed. The QAR data showed that a peak vertical acceleration of 2.1g had been recorded during the landing, confirming that the landing

was heavy. The data showed that both 'B' and 'C' autopilot channels annunciated flare capture four seconds prior to touch down and that the control column moved backwards to pitch the aircraft nose-up to flare. The control column then moved forward for a short time which caused the aircraft to start to pitch nose-down. The control column then began to move backwards again, at which point the autopilot was disengaged and a large manual nose-up control column input applied. The aircraft touched down two seconds later. The rate of descent had increased from 586 to 1191 feet per minute two seconds prior to landing.

The data showed that the wind direction had changed from 318° to 113° for one second during the flare, but with a wind speed of only 2 kt, this was not considered to be a significant factor.

The QAR data also confirmed that the autopilot was receiving accurate height data from the radio altimeters.

Engineering investigation

After the incident the 747 Maintenance Manual Chapter 5-51-05 Heavy Landing Inspections were performed. Damage was found to the keel beam behind the wing and on the Number 3 engine pylon skin. The pylon skin damage was repaired and after assessment the keel beam damage was considered acceptable for further service, subject to periodic re-inspection.

The validity of the radio altimeter data was established by checking the QAR data, which indicated that the radio altimeter system had been operating correctly.

The LCLUs were tested on the aircraft but as no faults were found and the component life histories for these units showed no history of related failures or early removals, it was not considered necessary to replace them.

Autoland Triple Channel Ramp Down checks were performed in accordance with 747 Maintenance Manual Chapter 22-00-00 with each of the three autopilot channels 'first in command'. These ground-based tests simulate an automatic approach and landing using dummy radio height, localiser and glideslope data signals supplied by test equipment. The approach and flare manoeuvre were performed satisfactorily in each case. No explanation could be found for the nose-down pitch during the flare.

The aircraft was returned to service and after completion of a successful automatic landing, the autopilot system was upgraded to triple autopilot landing operational status. The aircraft has since performed several successful automatic landings. As a precaution, the airline continued to monitor the performance of the autopilot for a short period. The aircraft has no history of this problem and no further problems have been reported since this incident.