Boeing 737-59D, G-BVKA

AAIB Bulletin No: 3/97 Ref: EW/C96/8/2 Category: 1.1

Aircraft Type and Registration:	Boeing 737-59D, G-BVKA
No & Type of Engines:	2 CFM56-3C1 turbofan engines
Year of Manufacture:	1990
Date & Time (UTC):	6 August 1996 at 0727 hrs
Location:	Stand C30, London Heathrow Airport
Type of Flight:	Public Transport
Persons on Board:	Crew - 7 - Passengers - 37
Injuries:	Crew - Nil - Passengers - Nil
Nature of Damage:	Auxiliary Power Unit damaged beyond repair
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	39 years
Commander's Flying Experience:	5,800 hours (of which 4,450 were on type)
	Last 90 days - 177 hours
	Last 28 days - 43 hours
Information Source:	AAIB Field Investigation

History of event

Following an uneventful flight from Paris, the crew started theAuxiliary Power Unit (APU) shortly after landing on Runway 09Lat London Heathrow. After a short taxiing distance, the aircraftwas parked on Stand C30, electrical power was transferred to theAPU and the engines were shut down. During the subsequent turnround period, the APU continued to supply the generator busbarsand also provided pneumatic air to the left air conditioning packwhich, together with the recirculation fan, was used to provideair conditioning.

In preparation for the subsequent scheduled flight to Paris, thepassengers began boarding as the crew were completing their flightdeck checks. The commander then became aware of an electricalburning smell and asked the first officer if he could smell it. Because there was some doubt, the flight service manager (FSM)was called to the flight deck for her opinion. The commander,as a precaution, then decided to switch off the recirculationfan and to pull the

associated circuit breaker. Leaving the firstofficer to monitor the situation on the flight deck, the commanderthen left the aircraft to investigate the cargo holds since hewas concerned in case the smell was originating from smoulderingwiring, baggage or freight. Instructing the baggage loaders toinspect the rear hold, he carried out an inspection of the electricaland electronic equipment bay and the front hold, but nothing abnormalwas found. However, when he returned to the flight deck, he wasimmediately aware of the burning smell. Additionally, co-incidentwith his arrival back on the flight deck, the APU electrical supplytripped off line and the 'Maint' and 'Fault' lights illuminatedon the APU forward overhead panel. Although there was no indicationof an APU fire, the commander was concerned with the deterioratingsituation and decided to disembark the passengers. He immediatelycalled the FSM to the flight deck and instructed her to disembarkthe passengers through the forward door and for the cabin crewto then leave the aircraft. While the FSM was carrying out thecommander's instructions, the flight crew selected standby powerand called ATC to ask for the Rescue and Fire Fighting Service(RFFS). The aircraft was then quickly secured and the flightcrew left the aircraft.

Just after the commander had returned to the flight deck afterhis inspection of the cargo holds, witnesses on the apron hearda loud 'bang' and saw an object ejected from the rear of the aircraftwhich struck the concrete apron some 6 metres to the rear of theaircraft. While the commander briefed the RFFS on the situation,the first officer left the flight deck to investigate the witnesses'observations and located a large and extremely hot metal componentamongst some apron vehicles which were parked about 70 metreson the right side of the aircraft. Examination of the componentby the operator's engineers identified it as the APU turbine wheelhub.

Subsequent investigation

Subsequent inspection of the aircraft and the APU confirmed thatthe turbine wheel hub had been released and had been ejected fromthe APU exhaust duct. The damage to the aircraft was limitedto a small hole; spiral contact marks, made by the turbine wheelhub, were evident in the APU exhaust duct.

The APU was removed from the aircraft and taken by AAIB to themanufacturer for strip examination. This revealed that therehad been a gradual failure of the No 1 bearing which had led tothe main rotor shaft, on which both the compressor and turbinewheel were mounted, moving forward. This displacement had allowedthe compressor impeller blade leading edges to contact the abraidablematerial of the air inlet housing and the forward face of theturbine wheel to contact the non-rotating seal plates. The associatedfrictional heating had caused melting of the wheel and the lossof sufficient turbine blade tip material to reduce the turbinewheel diameter to less than that of the internal diameter of theexhaust nozzle. The resulting imbalance of the main rotor assemblythen induced a failure of the tie bolt just forward of the turbinewheel.

The manufacturer initially considered that the No 1 bearing failurehad been due to contamination of the bearing. However, theirsubsequent analysis of the failure was unable to prove whetherit had been induced by contamination or had been due to a fatiguefailure of the bearing which had previously occurred in otherunits. The manufacturer has stated that the risk of similar failureswill be reduced by a direct lubrication design improvement whichhas been developed by them and is expected to be incorporatedinto production units by 1998. The manufacturer's bearing analysisalso revealed that the thrust loads on the bearing in-servicewere lower than predicted, which can result in ball 'skidding'and bearing failure as occurred in this case.

The manufacturer issued a Service Bulletin in August 1996 whichintroduced additional magnetic plug and oil filter element examinationsfor APUs with less than 1500 hours running time since manufacturer,or overhaul. The manufacturer is also designing a device whichwill prevent a released turbine wheel being ejected from the exhaustduct, with a view to this modification being available for fitmentduring 1997. In the longer term, the No 1 bearing will be redesignedto withstand the actual thrust loads that are generated by therotor system.

Safety Recommendation

As a result of the findings arising from this investigation, thefollowing Safety Recommendation is made:

97-3: In order to reduce the potential incidence of turbinewheel separation and release from APS 2000 auxiliary power units,the FAA should actively progress with the manufacturer the currentprogram to develop the retention device for the turbine wheelto retain it within the turbine containment zone. Additionally,the direct lubrication modification for the No 1 bearing and redesignof this bearing for improved life should be implemented as soonas possible.