Engine vibration on climb, Airbus A321-211, F-GTAF

Micro-summary: **While climbing, erratic engine vibration indications on this A321 prompt a return to base.**

Event Date: **2002-04-21 at 0835 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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Airbus A321-211, F-GTAF

AAIB Bulletin No: 7/2004	Ref: EW/G2002/04/11	Category: 1.1
INCIDENT		
Aircraft Type and Registration:	Airbus A321-211, F-GTAF	
No & Type of Engines:	2 CFM56-5B3/P turbofan engines	
Year of Manufacture:	1998	
Date & Time (UTC):	21 April 2002 at 0835 hrs	
Location:	5 miles south of London Heathrow Airport, Middlesex	
Type of Flight:	Public Transport	
Persons on Board:	Crew - 7	Passengers - 162
Injuries:	Crew - None	Passengers - None
Nature of Damage:	Right engine No 4 bearing failure	
Commander's Licence:	Airline Transport Pilot's Licence	
Commander's Age:	42 years	
Commander's Flying Experience:	6,700 hours (of which 280 were on type)	
	Last 90 days - 200 hours	
	Last 28 days - 80 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot and additional enquiries by the AAIB	

Three to four minutes after takeoff from Heathrow, while climbing to 6,000 feet under radar control, the commander noticed a significant increase in N2 (high pressure spool) vibration indications for the right (No 2) engine. He mentioned this to the first officer, who was flying the aircraft manually. A few seconds later, passing 3,500 feet, the engine experienced a surge accompanied by a lot of noise and considerable airframe vibration.

The commander actioned the 'Stall Reduction' (sic) procedure and retarded the No 2 engine to flight idle. Immediately the vibration and noise ceased and so, with the engine remaining at idle, he transmitted a distress message, requested radar vectors toward a landing back on Runway 27L at Heathrow, and for attendance by the Fire Service on landing. In his statement, the commander praised the assistance provided by the Air Traffic Controllers. With a total airborne time of 14 minutes, the aircraft made an uneventful landing on Runway 27L and, after an inspection by the

Fire Service as the aircraft vacated the runway, it was taxied back to a parking stand, where the passengers were deplaned normally.

Engine examination

Strip examination of the engine confirmed a failure of the No 4 bearing and initial examination of the bearing indicated that spalling of the bearing outer race was primarily responsible for the failure. This had led, in turn, to spalling of the rollers, which then resulted in failure of the cage spacers and, consequently, to skidding of the rollers. The reason for the initial outer race spalling could not be established.

The damage observed in this bearing would have led to greatly increased bearing drag and, consequently to a reduction in the Low Pressure shaft speed (N1). This in turn, would have resulted in a shaft speed mismatch with a reduction of airflow into the core engine. These conditions would be favourable to inducing the engine to surge, particularly at high power settings.

The engine had been in service for 1,033 hours/751 cycles since new. The failed No 4 bearing was part number 305-355-717-0, one of several standards which had been in service up to the time of this incident.

History of No 4 bearing failures

The No 4 bearing is the inter-shaft roller bearing between the High Pressure and Low Pressure rotors and lies within the LP turbine module at the rear of the engine. The inner race, with the rollers and cage, are mounted on the LP shaft and the outer race is mounted in the rear of the HP spool. It is common to all models of the CFM56 engine and has been, over time, the least reliable of its five principal shaft bearings. The bearing design and manufacturing process has evolved several times in attempts to reduce the number of failures and prior to this failure, four standards of No 4 bearing, with differing part numbers, had been discontinued and stocks withdrawn from availability. Between 1998 and April 2002 there were 15 failures of No 4 bearings on CFM56-7 engines, with many more on other CFM56 models. This, although regarded as unsatisfactory, represented less than 1% of the bearing population with a Mean Time Between Failures of 800,000 hours.

The same component, but with a different part number, had failed on a Boeing 737 aircraft, EI-CSA, on 27 February 2002 (see report in this edition of the AAIB Bulletin). At the time of the incidents involving EI-CSA and F-GTAF, three standards of No 4 bearing remained applicable for the CFM56-7 engine, including the -901 fitted to the engine from EI-CSA and the -717 in this case. A review of statistics showed that the -901 bearing, although one of the more recently introduced, was performing below the average of all the standards of this bearing and, as a result, it was decided to discontinue production of this part number also and withdraw stocks. The failed bearing fitted to F-GTAF was a -717 standard part number, which had one of the best service records and which has been in production since 1986.

It was evident, from data supplied by the engine manufacturer, that more than 80% of failures occurred within 6,000 hours of installation, of which more than half failed within 2,000 hours. The data also showed that there was little difference in the failure rates in new engines as compared to those which had been overhauled. From this, the manufacturer inferred that the bearing was particularly prone to mishandling or damage during installation, or during module splitting and refitting at engine workshop visits, and could be particularly susceptible to contamination or manufacturing variability.

The findings of investigations, by the manufacturer, into previous failures supported this and also indicated that the predominant primary cause of failure was spalling of the bearing outer race. To counter possible workshop mistreatment of the bearing, the manufacturer had instituted changes to Maintenance Manual procedures and working practices, emphasising the sensitivity of the bearings to mishandling and corrosion. This was done by issuing, in October 1999, a Service Memorandum (CESM No 054) on the subject of Optimizing Bearing Care - Good Practices, which brought together descriptions of those practices which minimised the potential for damage to be caused to bearings during workshop visits, transport and storage. Since the introduction of these changes an improvement in the reliability of No 4 bearings has been observed.

In a further development of the bearing, the manufacturer changed the material and surface treatment of the bearing outer race in order to overcome the potential spalling problem. Tests have indicated that this new outer race was considerably more resistant to typical installation damage and such damage as was sustained was much slower in propagation than with the earlier standard of outer race material. All currently available No 4 bearings are manufactured with the new outer race material.

In another endeavour to reduce the in-flight shutdown rate, the manufacturer had developed a portable vibration monitoring tool to detect incipient failures of No 4 bearing, for use both in test-cells or during ground runs. This has proved effective at identifying No 4 bearings with pre-failure conditions or damage believed likely to develop into complete failures. The engine manufacturer, CFMI, together with Boeing and Vibrometer have jointly developed an advanced version of the AVM system, for CFM 56 powered versions of the Boeing 737, using the existing engine mounted accelerometers. This, in addition to the functions already performed by the current AVM system, specifically monitors the health of the No 4 bearing to give maintenance engineers information that a degraded bearing state may exist.