

INCIDENT

Aircraft Type and Registration:	Concorde, G-BOAA	
No & Type of Engines:	4 Rolls-Royce Olympus 593/6/10 turbojet (with reheat)	
Year of Manufacture:	1975	
Date & Time (UTC):	7 June 1995 at 2046 hrs	
Location:	Over North Atlantic Ocean	
Type of Flight:	Public Transport	
Persons on Board:	Crew - 7	Passengers - 40
Injuries:	Crew - None	Passengers - None
Nature of Damage:	Severe damage to compressor of No 2 engine	
Commander's Licence:	Airline Transport Pilot's Licence	
Commander's Age:	50 years	
Commander's Flying Experience:	14,507 hours (of which 3,138 were on type) Last 90 days - 116 hours Last 28 days - 36 hours	
Information Source:	AAIB Field Investigation	

The aircraft left John F Kennedy Airport, New York at 1846 hrs on a scheduled flight to London Heathrow Airport. The aircraft was assigned track "SN" and established in cruise-climb at FL550, M2.0; the first officer was the handling pilot. At about 30° west, the No 1 and 2 engines surged; the memory items of the CONTINUOUS ENGINE SURGE ABOVE M = 1.3 drill were carried out. If the surge stops after the initial actions, the throttles may be advanced singly; if no further surge occurs, the aircraft may revert to normal flight plan. This was done and, using reheat, the aircraft was accelerated from M1.35 to M1.7 when the reheats were switched off. All engine parameters appeared normal during the acceleration.

At about 22° west, M1.8, the No 2 engine again surged. As required by the drill, the throttles were returned to idle, speed was reduced to subsonic and a descent was initiated to FL330; the drill allows the engine to be used at the highest surge free power setting. The commander decided to continue the

flight subsonically to London Heathrow where it landed without further incident at 2231 hrs. The fuel remaining on landing was 10,500 kg; the required reserve fuel was 6,500 kg, with an additional 3,500 kg for the diversion to London Gatwick Airport.

After an initial inspection, with the engine still installed in the aircraft, had revealed that there was considerable damage to the blades of stages 2 & 3 in the High Pressure (HP) compressor, the engine was removed from the aircraft for strip examination. After removal it was seen that there was also a tear in the leading edge of one blade in the second stage of the Low Pressure (LP) compressor. It could also be seen, at this juncture, that there was some metal spatter on the LP turbine and in the exhaust diffuser. Since foreign object damage (FOD) was suspected at this point, a rigorous inspection of the engine intakes was made but this did not reveal any evidence of the passage of a foreign body; neither was there any component or fastener observed to be missing.

The strip examination of the engine showed that all stages of the HP compressor had suffered hard object damage, as had the trailing edges of the rearmost stage of the LP compressor. The severity of the damage in the HP compressor was observed to reduce progressively towards the rear of the compressor. It was also observed that one of the 1st stage HP blades had a relatively flat fracture with characteristics consistent with fatigue failure at about half blade height. The compressor damage seen was consistent with that to be expected to result from the release of a substantial part of a first stage HP compressor blade. This could damage other compressor blades, downstream, sufficiently to cause a deterioration of the compressor efficiency to the degree that the engine would surge. The resulting forward flow of blade debris filled air would then cause damage upstream of the initial failure.

An analysis of recorded engine data showed that the engine efficiency deteriorated sharply over the space of 6 seconds immediately before the initial two engine surge, which would be consistent with the foregoing postulation. The disturbance to the airflow in the intake of the adjacent engine, resulting from a surge, is known to be sufficient to cause the second engine to surge sympathetically. The recorded data showed that a transient sympathetic surge of the No 1 engine also occurred when the No 2 engine surged whilst being re-accelerated.

Laboratory analysis confirmed that the failure of the HP1 compressor blade had been by a fatigue mechanism which had initiated at the trailing edge of the blade where there had been some mechanical damage. The fatigue had progressed through four recognisable major cycles, each of which contained a consistent sub-cycle. There is no knowledge to determine what these cycles show but logically they would be likely to represent either one or two flight cycles. The engine had been installed in the aircraft some 50 hours and 16 flight sectors before the incident flight which had been operated almost exclusively on London Heathrow to New York-Kennedy schedules.

An analysis of smears at the point of initiation revealed the presence of A286 steel on the surface of the titanium alloy blade. There was also evidence, on isolated blades and stators of all stages in the LP compressor, in particular the already noted tear in the leading edge of an LP2 blade, of the passage of a hard object. Analysis of these smears also showed the presence of A286 steel. This steel is widely used in the aircraft industry for bolt, nuts and other types of fastener.

The operator has, for some time, been requiring duplicate inspections of intakes whenever any work has been performed in them; it also pursues a policy of very strict ramp cleanliness for Concorde operations but has no control over the cleanliness of other airfield areas.