Rejected takeoff, Boeing 767-3YOER, ZS-PBI, London Gatwick Airport

Micro-summary: **A rejected takeoff by this Boeing 767 led to a landing gear fire.**

Event Date: **2005-07-11 at 1951 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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ACCIDENT

Aircraft Type and Registration:	Boeing B767-3YO ER, ZS-PBI
No & Type of Engines:	2 Pratt & Whitney PW4000 series turbofan engines
Year of Manufacture:	1992
Date & Time (UTC):	11 July 2005 at 1951 hrs
Location:	London Gatwick Airport
Type of Flight:	Public Transport (Passenger)
Persons on Board:	Crew - 11 Passengers - 207
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to tyre treads on two wheels
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	51 years
Commander's Flying Experience:	17,800 hours (of which 1,460 were on type) Last 90 days - 170 hours Last 28 days - 90 hours
Information Source:	AAIB Field Investigation

Synopsis

As the aircraft approached V_1 during the takeoff, a problem was detected by the crew with the No 1 (left) engine. The takeoff was rejected and the aircraft brought to a halt clear of the runway. The airport fire service arrived very promptly at the aircraft, extinguishing small fires which has started in the left and right main landing gear wheels. After the passengers had disembarked and been bussed to the terminal, the aircraft was towed to a stand.

Data on the 30 minute cockpit voice recorder covering the rejected takeoff was lost as this had been overwritten before it was isolated. Three safety recommendations are made relating to this standard of recorder.

History of the flight

The aircraft was departing from Runway 08R at London Gatwick Airport (LGW), on a scheduled flight to Johannesburg, at a gross takeoff mass of 183,981 kg. This was close to the maximum allowable takeoff mass of 184,612 kg. A reduced Engine Pressure Ratio (EPR) of 1.53 was selected for the takeoff and all proceeded normally until the aircraft had reached an indicated airspeed (IAS) of about 150 kt. At this point the co-pilot, who was the flying pilot (PF), noticed a 'flash' out of the corner of his left eye and heard a bang, followed by the aircraft yawing to the left. He looked at the engine gas temperatures (EGTs), saw that they were normal and returned his attention to the flight instruments. The commander also felt the aircraft yaw and heard a 'dull thump'. He looked at the engine instruments and noticed

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that the left engine (No 1) N_1 gauge (low speed rotor/ fan section) needle was indicating about half full scale deflection and was increasing. He also noticed that there was no digital reading on that gauge. The commander heard a second 'thump' and saw the No 1 N_1 needle drop well below half scale deflection. Since the IAS was still less than V_1, which was 161 kt, he immediately called "stop", took control and carried out the procedure for a rejected takeoff. Reverse thrust was applied, as well as automatic Rejected Take Off (RTO) braking, and the crew reported that the engines behaved correctly as the aircraft decelerated.

The co-pilot advised ATC that they were rejecting the takeoff and requested the attendance of the Airport Fire and Rescue Service (AFRS) because the aircraft's brakes would be hot. When the aircraft had reduced speed to a walking pace, it exited the runway via taxiway BR and was brought to a halt on Runway 26R, facing west, as instructed by ATC.

AFRS response

The aircraft stopped in block 42S, some 300 metres from the Fire Station, and the AFRS response to the first call at 2048 hrs was very rapid, with the first appliances in attendance at the aircraft within one minute. On arrival, the AFRS informed the flight crew over the radio, on frequency 121.6 MHz, that there was a fire in the left main wheel assembly, which they were engaging. The flight crew were also advised by the AFRS that there was no need to evacuate the aircraft. After a minute, the AFRS informed the flight crew that they had extinguished the fire on the left main landing gear and requested that both the aircraft's engines be shut down. The flight crew did this, having started the APU, and released the parking brake. Meanwhile, the AFRS began to engage a brief fire which had started on the right main wheel assembly.

Two minutes after attending the aircraft the AFRS told the flight crew that the fires had been extinguished but that the brakes were extremely hot. While AFRS personnel continued to cool the brakes with a water mist, the flight crew communicated with the passengers, ATC and the airline's handling agent. Once the AFRS was satisfied that it was safe to do so, the passengers were disembarked from the aircraft via the forward left door, twenty two minutes after the takeoff had been rejected. They were then returned to the airport terminal by coach. A videotape of the incident showed that the fire crews were continuing to apply a mist to the tyres and brakes at this point, correctly positioned ahead of, and behind, the wheels. Despite the heat generated in the RTO, none of the protective fusible plugs in the aircraft wheels had melted. Following an inspection by engineers, the aircraft was towed back on to a stand one hour after the takeoff had been rejected.

At the start of the airport's response to the incident, the local emergency services were informed and were kept advised of progress throughout. There were no injuries to any of the passengers or crew during this event.

The incident report prepared by the AFRS showed a response with three major appliances and one light tender. They applied a total of 15,000 litres of water, generally as a mist, and used no other media .

The AAIB later discussed the extent, duration and appearance of the fires with several of the firefighters who attended. There were minor inconsistencies but the general account was that the larger fire was around wheel Nos 2 and 6 (inboard wheels of the left main gear) and that the appearance of the fire was "yellow-orange". The fires were extinguished "within seconds" and, on the left gear, briefly extended above the height of tyre Nos 2 and 6.

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Meteorology

The weather conditions, as recorded by the flight crew from the Automatic Terminal Information Service (ATIS) prior to takeoff, were; surface wind 060º/10 kt, visibility greater than 10 kilometres, one to two octas of cloud at 4,000 ft temperature 24ºC, dew point 10ºC and a QNH pressure of 1031mb.

Recorded information

The aircraft was fitted with a Cockpit Voice Recorder (CVR) and a Flight Data Recorder (FDR). Both were successfully downloaded.

CVR

The CVR recorded 30 minutes of audio data. After filtering out a high level of extraneous noise, it was apparent that the recording began subsequent to the event, as the circuit breaker had not pulled at the time the engines were shut down, and therefore was of no assistance in the investigation. The start of the takeoff run (see FDR section) was at 1950 hours, and both engines had been shut down by 1957 hrs, some seven minutes later. There was, therefore, an opportunity to ensure the timely preservation of the recorded data in accordance with ICAO Annex 6 Part I, 11.6.

FDR

The FDR contained data covering just over 29 hours of operation prior to event. There were some anomalies with the recorded data that made the engine N_1 and the computed air speed parameters unreliable below 5.25% and 30.5 kt respectively, and so for the purpose of this report, values below this have been set to zero. All times stated are referenced to UTC. Figure 1 shows the pertinent parameters during the rejected takeoff.

The recording covering the RTO started at 1935 hrs, with the right engine N_1 speed rising, the aircraft moving and in a turn. The left engine was started at 1937 hrs after the brakes had been applied. With both engine temperatures stable, the left engine consistently ran cooler than the right by an average value of approximately 20ºC. This behaviour was mirrored in two of the three other recorded takeoffs, where the temperature differential, whilst never disappearing, reduced to smaller amounts. It is possible that the accuracy of the temperature sensors played a part in the temperature differential; there was insufficient information to make this judgement. Whilst stationary, the N_1 and N_2 values of both engines were the same, at about 25% and 65% respectively.

At 1942 hrs the brakes were released and the engine power was increased. The aircraft taxied with a ground speed of between 7 kt, in turns, and 25 kt, on straight sections of the taxiway. At 1950 hrs the aircraft was slowed to 12 kt and turned from the taxiway adjacent to the runway onto Runway 08R. The aircraft accelerated from half way through the turn, reaching 30 kt by the time the heading stabilised on the runway heading of 83ºM. At this point the auto thrust was engaged, in takeoff mode, and the aircraft continued to accelerate, with the engine parameters matched throughout the acceleration period. The N_2 values reached a maximum of just under 98%, five seconds after turning on to the runway. The rise in N1 and EPR started to stabilise shortly afterwards, although both continued to climb slightly throughout the takeoff run, and the EGTs continued to climb as the aircraft speed increased smoothly. Approximately 27 seconds after turning on to the runway, the N_1 of the left engine recorded a sharp drop from the previous 100% reading to a value of just over 70%. In the next second this recovered to 97% but the N_2, EPR and fuel flow values showed a drop. Over the next four seconds the N1 remained erratic and

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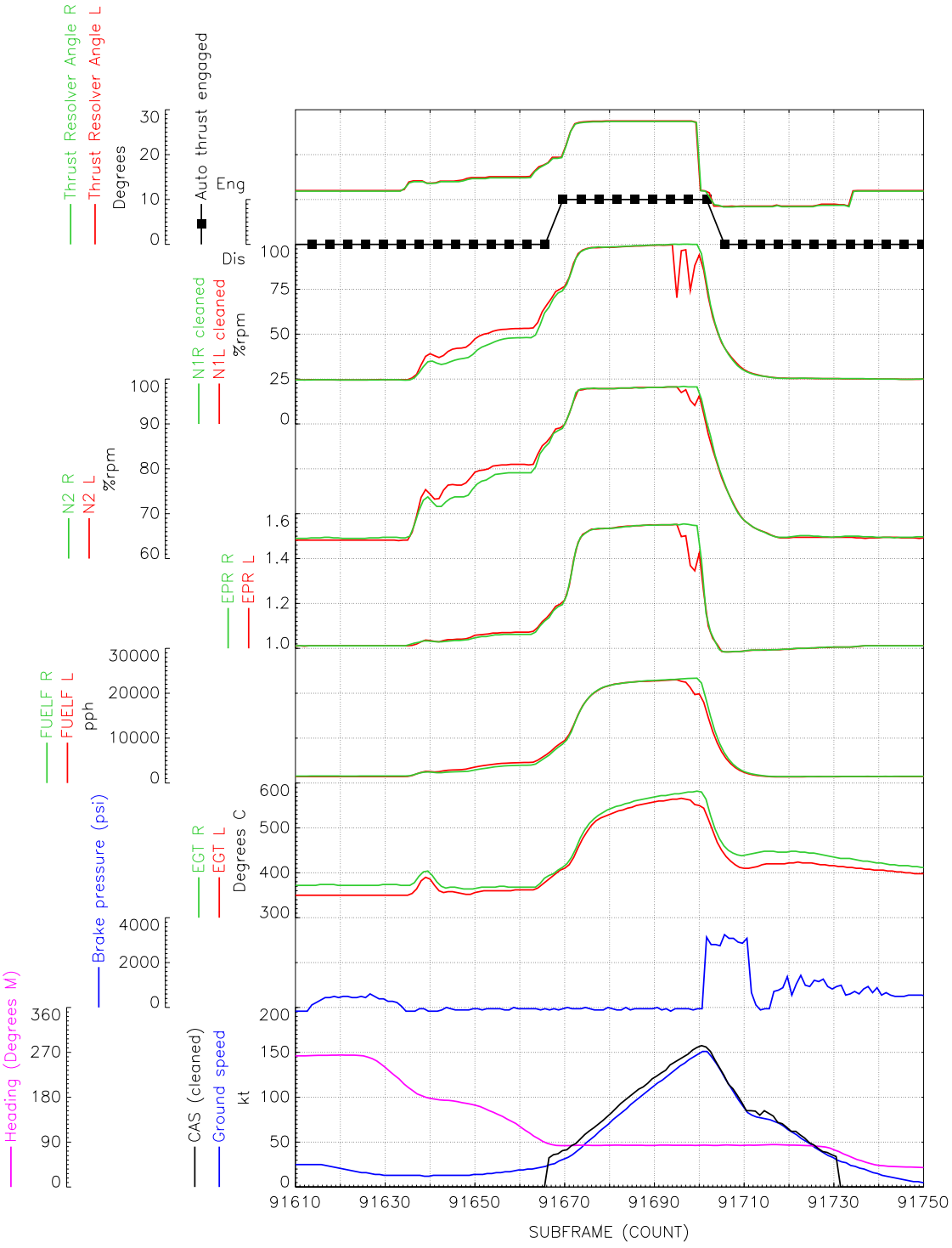

Figure 1

Recorded engine parameters during the rejected takeoff.

the N_2, EPR and fuel flow values decreased, at which point the thrust levers were retarded and the brakes were applied.

The highest calibrated air speed recorded was 157.5 kt and there was no indication of any rotation being initiated. After the takeoff was rejected the engine

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parameters converged. With the aircraft's computed air speed dropping through 80 kt, the braking action was relaxed for about five seconds and then re-applied with a reduced brake pressure. Throughout the takeoff run, the autobrake was armed and in RTO mode, and the thrust management computer was active in thrust/takeoff modes. The wheel well fire indication parameters were not triggered.

The aircraft was taxied and came to a halt at 1954 hrs, approximately 2 minutes and 40 seconds after the takeoff was rejected. At 1956 hrs the right engine was shut down and the recording ended at 1957 hrs, probably due to the shut down of the left engine; no master warning or caution alerts were triggered. The oil pressure, temperature and quantity parameters did not show any anomalies throughout the event and no engine fire or engine bleed overheat warnings were triggered. Also, the Electronic Engine Control (EEC) system related parameters did not show any anomalies.

Examination of the aircraft

The AAIB examined the aircraft on the evening of the incident in conjunction with the maintenance organisation. At this time, the carbon brakes were still warm and it was apparent that the fusible plugs in the wheels had not melted. The maintenance organisation performed the conditional inspections detailed in the manufacturer's Maintenance Manual (MM) section for a High Energy Stop (767 MM 05-51-14). For aircraft without brake temperature monitoring on the EICAS[1], such as ZS-PBI, these inspections require the use of an extensive chart to determine the approximate dissipated energy per brake unit and the likely maximum brake temperatures. Because of the high takeoff mass of the aircraft and the high maximum speed of the RTO, this chart indicated that the highest temperatures likely to have been achieved were in the 'brake temperature monitor' range of 8; well within the wheel 'Fuse plug melt zone'.

If the derived temperatures are in this zone, the Brake Energy chart notes require the crew to clear the aircraft from the runway, not to set the parking brake, not to approach the landing gear and not to attempt to taxi within one hour. In this case, it is likely that the application of the water mist to the tyres by the AFRS removed sufficient heat which prevented the fuse plugs from melting and hence the tyres deflating.

However, the aircraft's manufacturer's Maintenance Manual includes the following warning:

> *'DO NOT APPLY EXTINGUISHER OR COOLANT DIRECTLY ON THE INFLATED TYRE OR WHEEL. AN EXPLOSION CAN BE CAUSED AND INJURY TO PERSONS CAN OCCUR'.*

In discussion with the aircraft manufacturer on this issue, they commented that this warning is not intended to limit the activity of any AFRS.

Later detailed inspections of the brakes, wheels, tyres, hydraulic and electrical systems confirmed that no discernible damage had been done by the brief fires. The only items changed were two tyres which sustained physical tread damage during the RTO; damage unrelated to the fires.

Engine examination

The No 1 engine was removed by a working party from a Zurich-based maintenance organisation and

Footnote

[1] EICAS, Engine Indication and Crew Alerting System.

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a replacement engine installed. The suspect engine was sent for examination to an overhaul organisation in Singapore, where the subsequent examination did not show any physical anomaly within the engine. However, it appeared from the recorded data that the engine behaviour had probably been caused by an intermittently erroneous LP rotor speed (N_1) signal. Such a signal fault would cause the FADEC to schedule fuel flow in an unusual manner, with a rapidly decreasing fuel flow when the indicated N_1 increased, followed by a corresponding reduction in fuel flow when the N_1 signal returned to a more normal level.

Certification requirements

The certification requirements for large transport aircraft are principally specified in FAR Part 25 for the FAA and CS-25 (Certification Standards) for the EASA. With regard to braking systems, the requirements are essentially the same.

FAR 25.109 ('Accelerate-stop distance') describes a flight test equivalent to a maximum energy RTO, but does not include criteria as to whether a post-test fire is allowed to occur. FAR 25.735 ('Brakes and braking systems') specifies a five minute period for safe evacuation, as follows:

> *'Following the high kinetic energy stop demonstration .... it must be demonstrated that for at least 5 minutes from application of the parking brake, no condition occurs (or has occurred during the stop), including fire associated with the tire or wheel and brake assembly, that could prejudice the safe and complete evacuation of the airplane.'*

This is developed in the advisory material, AC 25.735-1:

> *'Regarding the initiation of a fire, it should be demonstrated that no continuous or sustained fire, extending above the level of the highest point of the tire, occurs before the 5-minute period has elapsed. Neither should any other condition arise during this same period or during the stop, either separately or in conjunction with a fire, that could be reasonably judged to prejudice the safe and complete airplane evacuation. Fire of a limited extent and of a temporary nature (e.g., those involving wheel bearing lubricant or minor oil spillage) is acceptable. For this demonstration, neither firefighting means nor coolants may be applied.'*

The short-lived fires at both main landing gears fell within the broad limits allowed by FAR 25.735 and its advisory material. A review of accidents to large transport aircraft indicates that the 5-minute 'post-RTO' period has, in almost all cases, allowed both for evacuation of the occupants and deployment of the fire services to the aircraft.

Analysis

The aircraft was departing near to its maximum allowable takeoff mass, on a warm evening. The takeoff was rejected at a speed which was approaching rotation speed, V_1, following a rapid assessment of a left engine fault by the flight crew. The recorded data supports this diagnosis and the actions taken. Before the takeoff roll commenced, there were no recorded indications of any problems with the engines or their control systems. During the takeoff roll, the left engine parameters indicated erratic N_1 values and a drop in engine performance but, after the rejected takeoff, the engine parameters, again, showed no anomalies.

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The prompt request for the attendance of the AFRS meant that the fires, which started on both the main landing gear wheel assemblies, were rapidly extinguished. The situation was under control throughout and all interested agencies inside and outside the airport were advised and kept informed. The radio frequency that was used for communications between the AFRS and the flight crew, 121.6 MHz, was recorded and proved to be of use during the investigation. This reflects the sentiments expressed in the AAIB report on a wheel fire event to a Boeing 777, AP-BGL (see AAIB Bulletin 1/2006).

With regard to the short-lived fires at both main landing gears, it is clear that they fell within the broad limits allowed by FAR 25.735 and its advisory material. Whilst this may appear permissable, a review of accidents to large transport aircraft does not indicate that any justification for stricter criteria for fires associated with brake systems is required: the 5-minute 'post-RTO' period has, in almost all cases, allowed both for evacuation of the occupants and deployment of the fire services to the aircraft.

In this particular incident, it is likely that the steady application of water mist by the AFRS prevented the melting of the fuse plugs in the main wheels. This would appear to be in contradiction of the instruction in the MM proscribing the application of '*extinguisher or coolant directly on the inflated tyre or wheel*'. However, the aircraft manufacturer comments that this instruction is only intended for maintenance activities and should not limit the activity of the AFRS.

Safety Recommendations

Had the CVR not been overwritten, further evidence, such as communications and engine noise, may have proved useful to this investigation. The installation of a 30 minute duration CVR on this aircraft, instead of one with a 2 hour duration, was a significant factor in the loss of significant recorded data, in addition to the circuit breaker not being pulled when the engines were shut down after the event. Often, the time between an occurrence of an incident and the first appropriate opportunity to isolate the flight recorders is greater than 30 minutes.

During a previous AAIB investigation involving an FAA registered aircraft (see N781UA, Boeing 777 N781UA, 14 July 2004, AAIB Bulletin 9/2005), the CVR evidence was lost in a similar manner. In the report on that incident Safety Recommendation Nos. 2005-051, 2005-052 and 2005-053, shown below, were made to the FAA and the JAA.

'Safety Recommendation 2005-051

It is recommended that the Joint Aviation Authorities, in common with the Federal Aviation Administration intent, mandate a minimum recording duration of two hours for all aircraft currently required to be fitted with a Cockpit Voice Recorder.'

'Safety Recommendation 2005-052

It is recommended that the Federal Aviation Administration and the Joint Aviation Authorities review their processes of oversight of Operator's procedures and training support to ensure the timely preservation of Cockpit Voice Recorder recordings in accordance with ICAO Annex 6 Part I, 11.6, following a serious incident or accident. The operator procedures and training should provide the necessary skills and information to identify accidents and serious incidents and implement the necessary tasks to preserve these recordings in a timely manner.'

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'Safety Recommendation 2005-053

It is recommended that the Federal Aviation Administration require [the operator], and any other airline regulated by the Federal Aviation Administration with similar procedures, to amend their procedures to ensure prompt identification of accidents and serious incidents and timely preservation of Cockpit Voice Recorder recordings.'

The JAA responded to these recommendations with positive intent. At the time of writing, the FAA had yet to respond to the recommendations. These recommendations are also appropriate to this investigation and hence are now addressed to the South African Civil Aviation Authority.

Safety Recommendation 2006-061

It is recommended that the South African Civil Aviation Authority, in common with the Federal Aviation Administration intent, mandate for a minimum recording duration of two hours for all aircraft currently required to be fitted with a Cockpit Voice Recorder.

Safety Recommendation 2006-062

It is recommended that the South African Civil Aviation Authority review their oversight processes of Operator's procedures and training support, to ensure the timely preservation of Cockpit Voice Recorder recordings in accordance with ICAO Annex 6 Part I, 11.6, following a serious incident or accident.

Safety Recommendation 2006-063

It is recommended that the South African Civil Aviation Authority require Nationwide Airlines, and any other airline regulated by them with similar procedures, to amend their procedures to ensure the timely preservation of Cockpit Voice Recorder recordings in the event of an accident or serious incident.

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