AAIB Bulletin No: 7/94 **Ref: EW/C94/3/1** **Category: 1.1**

Aircraft Type and Registration:	Boeing 767-200 ER, Z-WPE
No & Type of Engines:	2 Pratt & Whitney PW4056 turbofan engines
Year of Manufacture:	1989
Date & Time (UTC):	10 March 1994 at 1819 hrs
Location:	London Gatwick Airport
Type of Flight:	Public Transport
Persons on Board:	Crew - 12 Passengers - 125
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to brakes and hydraulic system on both main landing gears
Commander's Licence:	Zimbabwe Airline Transport Pilot's Licence
Commander's Age:	52 years
Commander's Flying Experience:	13,500 hours (of which 1,700 were on type) Last 90 days - 76 hours Last 28 days -135 hours
Information Source:	AAIB Field Investigation

History of the flight

The aircraft left london Gatwick Stand 57 at 1805 hrs on departure for Harare, Zimbabwe. It lined up on Runway 26 Left and began the take-off roll at 1818 hrs. The aircraft weight was 164,000 kg and the V_1 speed was 155 kt with V_R at 160 kt. Full take-off thrust was used and, during normal acceleration, the non handling first officer called "80 knots". Shortly afterwards the pilots' attention was drawn to the first officer's Direct Vision (DV) window which had cracked open at its rear edge and was making an increasingly loud noise. The commander instructed the first officer to close the DV window but he was unable to do this. The commander realised that they were both becoming distracted by the window problem and, considering that an unsafe situation was developing, he decided to abandon the takeoff and pulled back the thrust levers. The automatic rejected takeoff mode (RTO) activated and applied maximum auto braking together with spoiler deployment once reverse thrust had been applied by the commander. The aircraft decelerated normally, passing the last rapid exit turn-off at about 80 kt, and stopping at the end of the runway before turning off to the right. The commander asked ATC if there was any sign of smoke or fire from the landing gear and was told that

none could be seen. He then asked for the Fire Rescue Service to conduct an examination of the wheels and brakes before moving the aircraft. Some leakage of hydraulic fluid was discovered during this inspection. The passengers were disembarked using the normal exits and taken by bus to the terminal. The aircraft was later towed back to the ramp area.

Engineering investigation

The aircraft was examined the same night on a stand at Gatwick. For the purposes of this narrative, the numbering convention adopted to describe the position of each mainwheel/brake assembly follows the Boeing nomenclature, viz: No 1 being the forward left-most wheel and No 4 being the furthest right. The rear wheels are correspondingly numbered 5,6,7 and 8 from left to right.

As found, No 3 tyre had completely deflated and No 7 had a slow leak. Hydraulic fluid was dripping from ruptured pipes on both landing gears. It was obvious that the brake reaction rods had detached from brakes No 2,4,6 and 8. These reaction rods prevent the entire brake assembly rotating with the wheel (see Figure 1) and thus disconnection allows pack rotation with the consequential pulling-apart of the brake hydraulic hoses which was clearly what had happened.

In all cases, the disconnection was due to the absence of the brake attachment pin which had apparently migrated out from the torque arm/reaction rod. All four had been recovered from the runway together with their associated retaining cross-bolts (which had broken), nuts and washers. The No 2 brake featured a broken torque arm on the brake pack as well, which was also recovered. Subsequent metallurgical examination of the failed components showed that overload failures of the cross-bolts had allowed the pins to migrate out; the broken torque arm must have occurred before the pin was completely disconnected.

No abnormalities could be found with the operation of the co-pilot's window. which closed and locked without difficulty.

Previous instances of reaction rod disconnection

The brake friction surfaces fitted to Z-WPE were of carbon construction. Failures of the reaction rod load path have been a recognised problem with this type of brake on the Boeing 767. Readers are referred to AAIB Bulletin 4/94 for details of two incidents involving British-registered Boeing 767-300 aircraft which occurred in September 1993 and which also contains an overview of the problem and the proposed airworthiness actions designed to prevent recurrence.

Essentially, the phenomenon of brake reaction rod disconnection is, according to Boeing, due to 'squeal' vibration characterised by rotation deflection of the stationary brake components about the axle centrelines. This has manifested itself primarily as breakage of the cross-bolt and subsequent rapid migration of the attachment pin (as occurred on Z-WPE) . A smaller number of cases involved failure of the brake rod centre bolt (which implies loss of braking on a tandem pair of wheels) and one recorded failure of the torque arm (as occurred on Z-WPE). Although simultaneous loss of a tandem pair of attachment pins has occurred before, this incident is the first in which four wheels have been affected, albeit on different landing gear bogies.

After the instances of cross-bolt failure described in AAIB Bulletin 4/94, the CAA imposed a performance penalty, and other interim measures, on the two affected British operators of the Boeing 767 by assuming a possible braking efficiency loss equivalent to two brake units. Meanwhile, Boeing issued two Service Bulletins, No's 767-32-A0116 and 767-32-A0126. The former detailed a programme of inspection and replacement of the centre bolt and bushing whilst the latter included inspection of the bushing and a modification to replace the brake attachment pin cross-bolt with a revised arrangement featuring a 'keeper' pin. Finally, Boeing issued Service Bulletin No. 767-32-A0125 which introduced a revised quick-disconnect hydraulic fitting arrangement to address another, non-associated, problem which had caused loss of individual wheel braking.

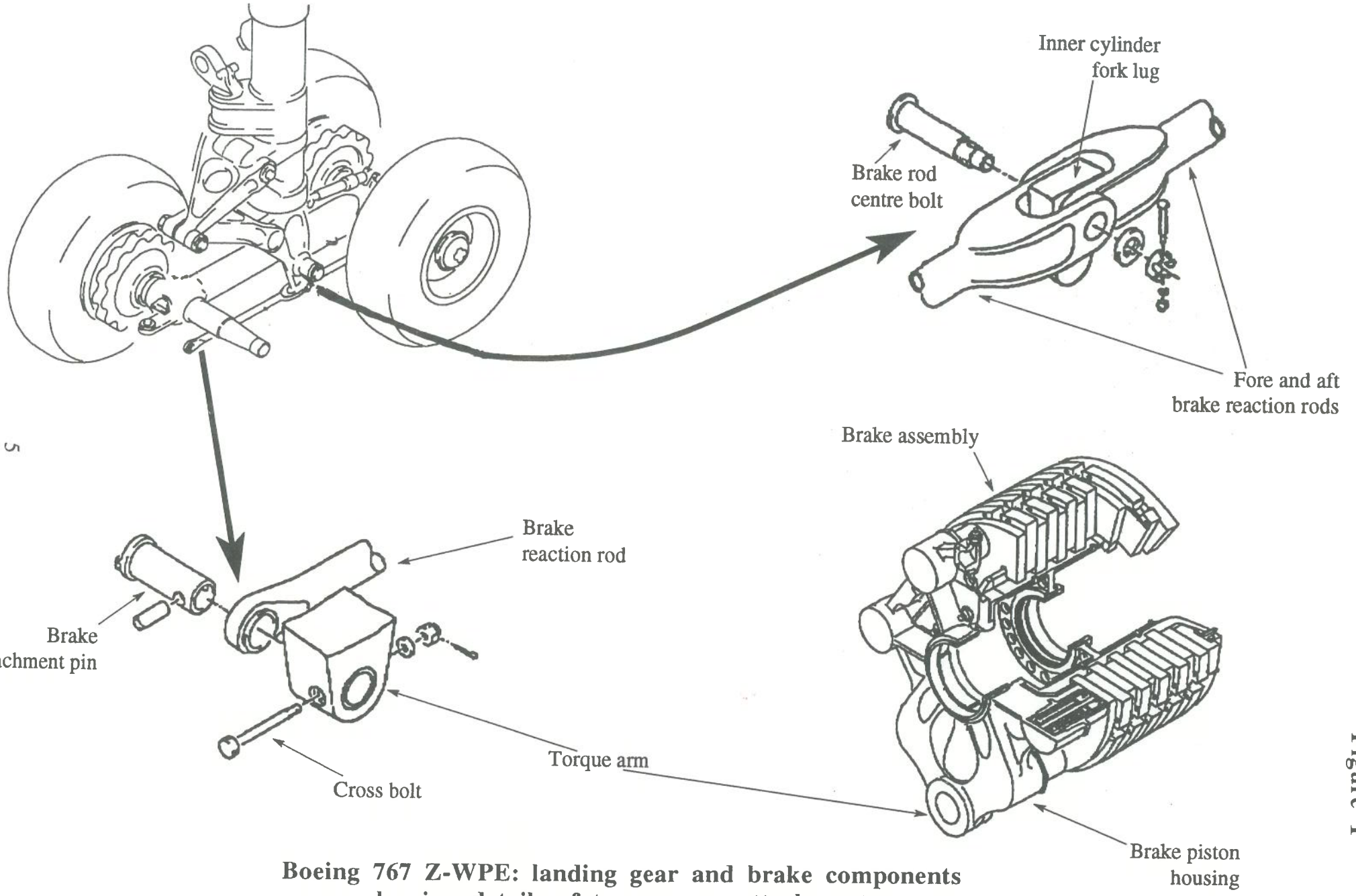
The FAA issued Airworthiness Directive (AD) 94-03-07 with an effective date of 18 February 1994 which mandated all three of the above Service Bulletins. It also included details of various performance penalty options should operators be unable either to comply with the AD inspection and modification requirements within the stipulated 60 days from the effective date or should defects be discovered which cannot be rectified within the compliance limitations detailed in the AD.

Z-WPE did not have the keeper pin modification installed but was well within the 60-day compliance time allowed by the AD for its incorporation.

Flight recorders

The Flight Data Recorder (FDR) was removed and replayed by AAIB. However, as the 30 minute Cockpit Voice Recorder would have overrun the period of the event, it was not removed or replayed. Figure 2 shows the relevant parameters from the FDR during the take-off run, the maximum speed reached was 141 kt when there was a spike in the longitudinal acceleration recording with a reduction in longitudinal acceleration of -0.314 g over 0.25 seconds. There was no recording of brake pressures on the FDR.

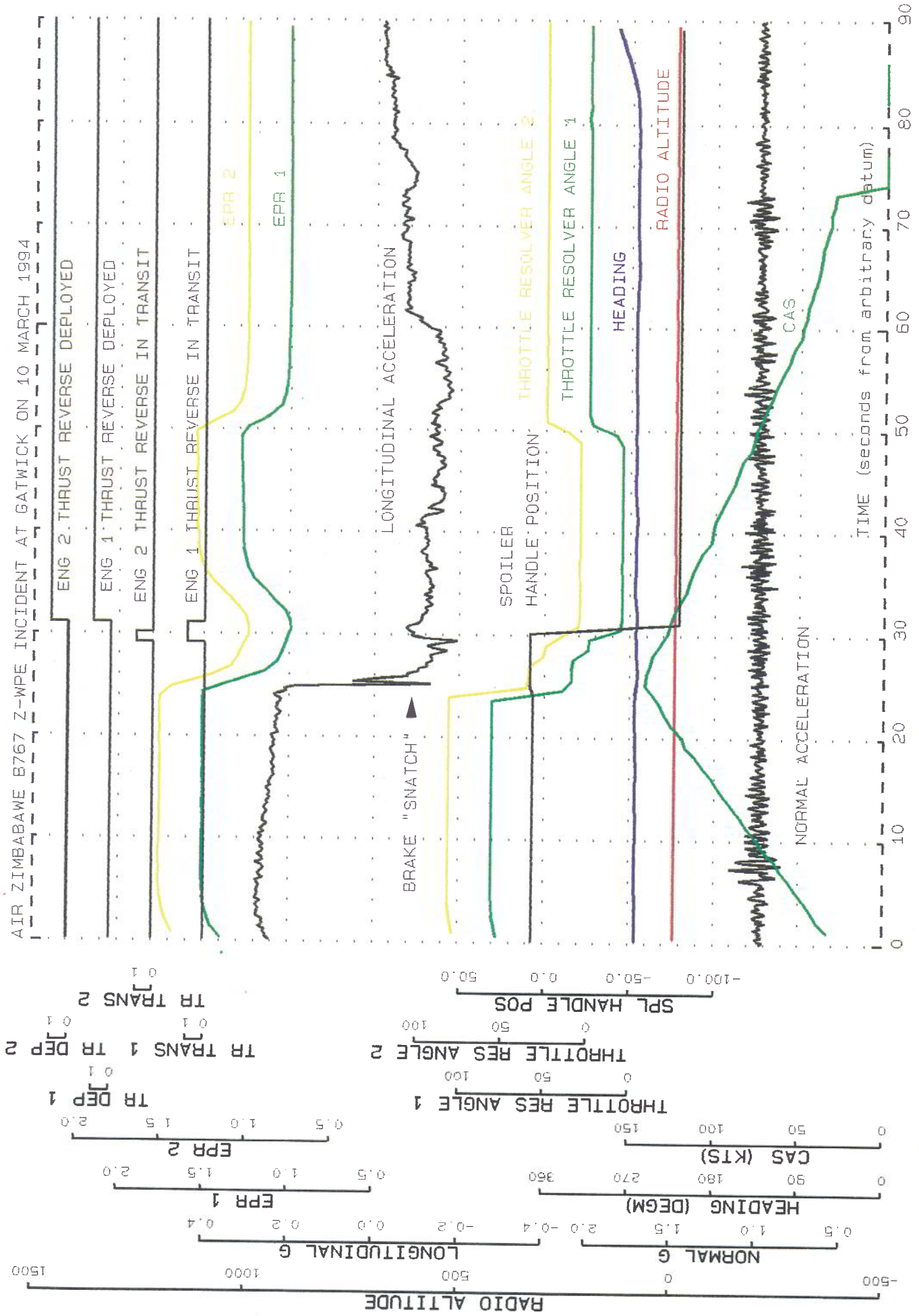
The 'spike' referred-to above appears to be associated with brake reaction-rod disconnections inasmuch as it also featured in the previous incidents described in the AAIB Bulletin. However, they have also been noted to a greater and lesser extent on aircraft which have not suffered a failure. British Airways have indicated that they are involved in a research programme which seeks to identify such events, which they believe are a form of brake snatch, from routine FDR replays.



Boeing 767 Z-WPE: landing gear and brake components showing details of torque arm attachments

Figure 1

Figure 2


AIR ZIMBABWE B767 Z-WPE INCIDENT AT GATWICK ON 10 MARCH 1994
ENG 2 THRUST REVERSE DEPLOYED
ENG 1 THRUST REVERSE DEPLOYED
ENG 2 THRUST REVERSE IN TRANSIT
ENG 1 THRUST REVERSE IN TRANSIT
EPR 2
EPR 1
LONGITUDINAL ACCELERATION
BRAKE "SNATCH"
SPOILER HANDLE POSITION
THROTTLE RESOLVER ANGLE 2
THROTTLE RESOLVER ANGLE 1
HEADING
RADIO ALTITUDE
CAS
NORMAL ACCELERATION
TIME (seconds from arbitrary datum)
0
10
20
30
40
50
60
70
80
90
TR TRANS 2
TR TRANS 1
TR DEP 2
TR DEP 1
SPL HANDLE POS
THROTTLE RES ANGLE 2
THROTTLE RES ANGLE 1
CAS (KTS)
HEADING (DEGM)
NORMAL G
LONGITUDINAL G
RADIO ALTITUDE
EPR 2
EPR 1