Boeing 757-300, 4X-BAU

AAIB Bulletin No: 7/2002	**Ref: EW/C2000/10/3**	**Category: 1.1**
Aircraft Type and Registration:	Boeing 757-300, 4X-BAU	
No & Type of Engines:	2 RB211-535 turbofan engines	
Year of Manufacture:	1999	
Date & Time (UTC):	3 October 2000 at 1953 hrs	
Location:	London Gatwick Airport	
Type of Flight:	Public Transport	
Persons on Board:	Crew - 10	Passengers - 224
Injuries:	Crew - Nil	Passengers - Nil
Nature of Damage:	Flap holed and wing undersurface panels split	
Commander's Licence:	Airline Transport Pilot's Licence	
Commander's Age:	59 years	
Commander's Flying Experience:	29,000 hours (of which 7,000 hours were on type) Last 90 days - 300 hours Last 28 days - 95 hours	
Information Source:	AAIB Field Investigation	

History of the flight

After an uneventful flight from Ben Gurion Airport, Tel Aviv, the crew made an ILS approach to Runway 26 Left at London Gatwick Airport. The commander was 'pilot not flying' (PNF) in the right seat and another captain was the 'pilot flying' (PF) in the left seat. Prior to commencing their approach, the crew had received ATIS Information 'Delta', timed at 1920 hrs, which broadcast the following information: "Runway in use 26 Left; surface wind 180°/10 kt; visibility 10 km or more; cloud, scattered two thousand feet; temperature +16°, dew point +13°; QNH 1015, QFE 1008." There was no significant change in ATIS Information 'Echo' timed at 1950 hrs. Along with their landing clearance, the crew were advised by ATC that the surface wind was 190°/ 9 kt. The landing was made with Flap 25 and Mode 2 autobrake selected in conditions of slight drizzle.

The crew considered that a normal landing had been made, touching down at approximately 135 kt, just beyond the PAPIs and slightly left of the runway centre-line. Shortly after touchdown the commander stated that the autobrake had disconnected. The PF acknowledged and reselected Mode 2 on the autobrake. The PF had selected reverse thrust and both pilots considered that retardation was normal until 100 kt when some vibration was felt. Around this time an engineer working on an aircraft to the north of the runway heard what he described as two separate distinct "bangs", separated by some 5 to10 seconds. The PF continued to slow the aircraft and, on the instructions from ATC, cleared the runway at fast exit 'Golf Romeo'. On initial check-in with the ground controller, the PNF advised that they would be holding position as they suspected a "flat tyre". The crew had also noticed an indicated loss of some hydraulic fluid contents in both Left and Right Systems. The controller cleared the crew to hold at 'Golf 1' and advised them that the AFS were on their way to inspect the aircraft. He also declared an 'Aircraft Ground Incident' and advised the tower controller. As a precaution, the tower controller instructed the next landing aircraft to go-around and then initiated a runway inspection.

The inspection revealed tyre debris on the runway and the runway was declared closed at 1955 hrs. By now, the AFS had inspected the aircraft and informed the crew that the two right rear tyres had burst. The passengers deplaned via the normal exits and the aircraft was then towed onto stand. The runway was swept and, following a further inspection, was declared open at 2044 hrs.

Flight Recorders

The two solid state flight recorders retained a record of the incident landing and were replayed by the AAIB.

The aircraft was configured for landing by 1,300 feet agl with speed brakes armed, Autobrake Mode 2 selected, 25° flap and gear down. The autopilot and autothrust were disconnected at 100 feet agl. Both thrust levers were brought back to idle at 20 feet agl. The aircraft touched down firmly (1.5 G normal acceleration) just before the PAPIs (440 metres from the landing threshold), slightly right wing down, at an airspeed of between 135 kt and 137 kt. Ground spoilers deployed automatically.

Recorded data showed a progressive increase in left and right system brake pressure and an increasing rate of deceleration until 3 seconds after touchdown. At that moment the left thrust lever was advanced briefly by 5° before idle reverse thrust on both engines was selected and the autobrake system mode selection changed to 'Disarm'. Both brake system pressures started to decay and aircraft deceleration reduced, with values from the longitudinal accelerometer recorded as changing from -0.168 G to -0.1 G, until progressive thrust reverser deployment again increased retardation.

Eight seconds after touchdown, with ground speed having reduced to 118 kt, autobrake Mode 2 was reselected and brake system pressure was observed to increase from zero. Within half a second of the autobrake mode change (approximately 500 metres from touch down), the right Main Landing Gear MLG) tilt sensor indicated that the truck had tilted (greater than 7° from the on-ground position) and aircraft roll attitude increased by 0.5° right wing down. It is considered that this was the point at which both rear tyres on the right MLG had failed. No variations in any of the other recorded aircraft parameters could positively be identified as resulting from the failure of the two subject tyres and it was not possible to determine at which point the first of the two failed. No sound associated with the failure of the tyres was detected on the cockpit voice recorder.

Aircraft deceleration remained relatively constant at an average of -0.16 G (consistent with Autobrake Mode 2 selection) down to a ground speed of 85 kt. At that point thrust reverse was cancelled and manual braking commenced (using less brake pressure than the 750 psi required to disarm the autobrakes). At 77 kt ground speed, the speed brake lever was lowered, stowing the ground spoilers and disarming the autobrakes. Symmetrical thrust reverse and braking was used throughout the deceleration phase and the aircraft remained close to the runway centre line as it slowed.

The aircraft vacated at fast exit Golf Romeo, was brought to a halt and the parking brake applied. Five minutes later, following discussion with the AFS, who by then were in attendance, the aircraft was moved forwards under its own power by approximately 10 metres. The parking brake was reapplied and the engines shut down, terminating the operation of both flight recorders.

Runway condition

Runway resurfacing had been completed and the runway swept on 29 September 2000 prior to re-opening. In accordance with the normal airport operating procedures, the runway had been inspected three times on 3 October; the last inspection had been completed at 1543 hrs. Nothing had been found on the runway on any inspection since 30 September. The operating companies for the two aircraft which took-off and landed immediately prior to the incident were contacted; both confirmed that nothing had detached from their aircraft.

Tyre debris was collected during the runway sweep following the incident. However, the sweeper vehicle is regularly used for clearing objects from the taxiways and dispersal areas and had not been emptied before the runway sweep; therefore, the possibility of debris on the runway that may have caused foreign object damage (FOD) cannot be discounted.

Tyre debris

Tyre debris found on Runway 26 was removed by the airport authority before the arrival of the AAIB personnel in order to allow the runway to be reopened. The available position information indicated that the debris had been situated between 1,550 and 2,130 metres from the landing threshold.

Aircraft Examination

Markings on the aircraft showed that tyre debris had struck the underside of the right wing, including the inboard trailing edge flap, the leading edge slat, the inboard flap track fairings and the right side of the fuselage/wing fairing. Strikes were also evident on the inboard side of the No 2 Engine nacelle and pylon, the right MLG doors and components of the right MLG. The inboard slat marking, a prominent 3x8 inch black smudge on the aft face of the slat in the plane of Wheel 8, showed that a portion of the tyre had been propelled forward with considerable speed relative to the aircraft. In general, the damage suggested that the debris from Tyre 8 had been somewhat more vigorous than that from Tyre 7. The following airframe components, all of composite construction with carbon fibre skin bonded to a nomex honeycomb core, were damaged:

1. 3x5 inch piece of the aft inboard flap punched out.

2. 24 inch long split in the outer skin of a wing lower skin panel forward of the right MLG bay.

3. 15 inch long split in the outer skin of a wing lower skin panel aft of the right MLG bay.

In addition, damage was apparent to the hydraulic flexible hoses installed on the right MLG, with two of the six hoses leaking (No 3 wheelbrake line and a bogie tilt actuator line). The forward flexible conduit carrying electrical cables had been struck by tyre debris but no cable damage was evident.

The pressures in the remaining MLG tyres found on the day after the accident were within limits at 205-210 psig, with the exception of Tyre 5 which, at 190 psig, was 5% below the minimum required pressure and 15 psi below the maximum allowable differential.

Tyre Examination

Examination showed that Tyres 7 and 8 had been destroyed, with only the two tyre side portions (bead and sidewall) remaining in place on each wheel. The remainder of both tyres was recovered from the runway. This included a number of large portions of tread, with carcass outer plies, constituting virtually the complete circumference of both tyres, and the complete shoulder-shoulder portion of two tyre carcasses (here referred to as the 'centre carcass'). Neither tyre tread showed any signs of skidding. Both centre carcasses had ragged edges, with a spaghetti-like appearance that was reported by the wheel and tyre manufacturers to be consistent with separation from the sidewalls due to overstress and overtemperature as a result of running with excessive tyre deflection. Detailed examination showed:

Tyre 7:

The centre carcass remained as a complete ring. No signs of FOD penetration or severe overtemperature of the centre carcass or sidewall remains were apparent. The tread, generally bonded to the outer 2-3 plies of the centre carcass, had split into three pieces. Damage in the base of one of the tread grooves that penetrated through the tread and outer carcass layers was consistent with a small FOD penetration prior to the tyre failure. No signs were found that the damage had extended through the inner layers or the liner of the carcass but the possibility could not be totally dismissed.

Tyre 8:

The centre carcass remained generally in one piece but with a complete rupture along a diagonal tear line. One edge of this tear exhibited some signs of the X-rupture pattern typical of tyre bursting. No signs of FOD penetration of the tread, centre carcass or sidewall remains were apparent. The sidewall remains showed signs of severe overtemperature, with evidence of reverted rubber and with bead wires exposed. The tread, generally including the outer 3-5 plies of the centre carcass, had split into two major pieces and three smaller pieces. The characteristics suggested that the more fragmented area of the tread had probably originated from the region of the centre carcass that exhibited the burst evidence.

The possibility that FOD or deterioration of one or both of the tyres had caused pressure loss prior to failure could not be dismissed in view of the severe roll-flat damage sustained.

Wheel Examination

The tyre sidewalls had deflected outwards, over the wheelrims, and neither wheel had contacted the ground and both were apparently undamaged. The inner edge of both wheel heatshields had suffered local deformation, consistent with contact by tyre debris. Visual inspection before and after splitting of the wheels revealed no signs of defects in the wheel split line seal components and eddy current checks showed no evidence of wheel cracking. The wheels were pressure checked by reassembling with replacement tyres fitted. Detailed examination and checks showed:

> *Wheel 7:*
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> Pressurisation to 100 psig (limited because of valve damage) revealed no abnormal leakage. The pressure relief valve was found to have impact damage on its outer corner, consistent with the effects of forcibly placing the inner wheel half onto a hard surface with the valve installed.
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> *Wheel 8:*
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> Pressurisation of the wheel to 190 psig revealed no abnormal leakage. All four fusible plugs remained in their threaded ports but were found to have inadequate tightening torque and could be unscrewed using light finger pressure directly on a socket spanner fitted to the hexagonal heads. Investigation failed to establish why the proper tightening torque was not present.

Aircraft History

The aircraft was delivered new to the operator on 31 January 2000 and had accumulated 2,734 flying hours and 782 flight cycles at the time of the accident. Wheels 7 and 8 had been installed on 4X-BAU approximately 200 flight hours prior to the accident. Neither had accumulated sufficient service to require overhaul. The tyres fitted to these wheels had each been re-treaded once (R1); records indicated that they had been reworked in accordance with the relevant specifications and that inspections had not revealed any anomalies. At the time of the accident, Tyres 7 and 8 had accumulated 249 and 162 flight cycles respectively since installation. Typical duty between retreads was likely to be in the order of 300 cycles.

4X-BAU's tyre inflation pressures had last been certified as correct during a 48 Hour Check on the day of the accident. The initial pressures found during this check were not recorded and no records were available to indicate whether there had been abnormal pressure loss from any of 4X-BAU's tyres in the weeks leading up to the accident. It was also unknown whether either tyre had at some point been overloaded because of under inflation of its partner.

A Tyre Pressure Indication System (TPIS), to provide flight deck indication of tyre pressures, is an option on some aircraft types but is not available for the Boeing 757. A wheel-mounted pressure gauge system providing indication of appreciable under inflation during pre-flight walk-round inspection is available for the 757. The system is not widely used on public transport aircraft and was not installed on 4X-BAU.

Gear tilt and air / ground sensing

Air/ground sensing on the aircraft is implemented using gear proximity and tilt pressure sensors feeding two, separate air/ground logic systems. To enable the main landing gear to fit into the wheel well and to facilitate air/ground sensing, each gear truck is designed to be tilted 9.6° aft during extension and retraction. The logic of the air/ground system is such that an 'on-ground' status is generated by either of the following conditions:

Both main gear trucks untilted (aircraft on the ground) or

One main gear truck untilted and the nose gear compressed.

After the failure of both tyres during the landing roll, the right gear truck was sensed as tilted only after the nose gear had been compressed and so the air/ground logic was unaffected by the circumstances of the failures.

Landing gear description

The 757-300, a stretched version of the 757-200, entered service in 2000. Each MLG has a conventional 4 wheeled bogie, with pairs of wheels mounted on two axles. The rear wheels of the right landing gear are designated as No 7 and No 8, from left to right. A carbon disc brake with a cylindrical metal heatshield is located within each wheel. The wheels are of forged aluminium, with a nominal bead seat diameter of 19 inches (BF Goodrich Aerospace Part Number 3-1581). Each consists of an inner and an outer half bolted together and sealed by an elastomeric packing ring. Threaded ports in the wheel inner half near the wheel tie bolts accommodate four fusible plugs, designed to release the tyre pressure if the wheel temperature exceeds approximately 390°F (199°C). The required installation torque for the plugs is 70 lb-in (dry); there is no provision for them to be mechanically locked (eg, wire locking). An overpressure relief valve (designed to rupture at 375-450 psig) and an inflation valve are fitted in threaded ports in the web of the wheel inner half. The plugs and valves are each sealed by an elastomeric packing ring.

Each MLG wheel is fitted with an H40 x 14.5-19 26PR bias-ply tubeless tyre (overall diameter x cross section width - bead diameter in inches & ply rating, Michelin PN 040-800-0) with a load rating of 36,800 lb and a speed rating of 235 mph. A generally similar tyre is used on the B737 and the B757-200, but with a 24 or 26 ply rating and a 225 mph speed rating. The tyre is of conventional construction, consisting of a casing of bonded layers of rubberised nylon cord laid crossply around steel wire bead cores, sealed on the inside by a relatively impermeable rubber inner liner and protected on the outside by a bonded rubber compound tread. The tyre is re-treadable a number of times, in line with normal practice, subject to satisfactory inspection of the carcass. It is generally accepted that the sensitivity of a tyre to abnormal operating conditions tends to increase with the overall operating life of the tyre casing, ie effectively increasing with the number of retread operations that the tyre had experienced.

Maintenance procedures

The aircraft manufacturer's Maintenance Manual recommended MLG tyre inflation to a pressure of 200-214 psig at the maximum Taxi Gross Weight of 273,500 lb, with tyres cold and supporting the aircraft weight. The minimum allowable pressure reduced progressively at lower weights. All MLG tyre pressures were required to be within ± 5 psi of each other. Inflation with dry nitrogen was specified, with limited topping up with dry air permissible.

Tyre scheduled line maintenance consisted of a visual check of tyre condition during the flight crew's pre-flight external check plus visual inspection and pressure checks every 48 hours elapsed time. The 48 Hour 'Check Sheet' used by the maintenance organisation, contracted by the operator to maintain the aircraft, specified MLG tyre inflation to 200-214 psig, with a tolerance of +1 / -5 psi between any tyre. It also noted:

"Note 3: If the tyre pressure is less than the necessary pressure by more than 15 percent replace that tyre and wheel assembly.

Note 4: If the tyre pressure is less than the necessary pressure by more than 30 percent replace both tyre and wheel assy (assembly) on that axle".

The time following landing at which the check should be carried out was not specified and no procedure was given in the event of finding pressures in excess of the specified values. The maintainer's normal practice was for a 'Check Sheet' entry to be made certifying that tyre pressures were within limits, but the pressures found before any necessary inflation were not recorded.

Recommendations published by the Tyre Division of the Rubber Manufacturers Association were for replacement of a tyre that had been in service with pressure 10% or more below the minimum loaded service pressure and for replacement of its axle mate also where the deficit was 20% or more.

Service Letters issued by the aircraft manufacturer on 13 July 2001, applicable to a range of aircraft models (757-SL-12-012 for the 757), recommended that 'tyre pressures be checked every 24 elapsed clock hours, whenever possible'. The Letter noted that 'Accelerated pressure losses from a wheel/tyre assembly are the primary reason for frequent pressure checks.' and that 'it is critical that tyre inflation pressure be checked often enough to ensure that heat build-up and fatigue damage are minimised.'

Previous cases

The available evidence indicated that there had been 7 previous cases of 757-300 tyre destruction in service. Two cases were attributed to FOD and the remaining 5 cases, all on the fleet of 2 aircraft operated since early 2000 by 4X-BAU's operator, had probably resulted from the effects of underinflation.

Investigation by the tyre manufacturer indicated that the rejection rate at their retread facility for this model of tyre was not excessive. However, the operator experienced a further failure, of a new (non-retreaded) tyre of the same type in January 2001. Examination of this tyre and another suspect tyre by the tyre and aircraft manufacturers reportedly identified a design and manufacturing problem associated with the alignment of fabric layers in the lower sidewall area. This had resulted in local deterioration and eventual rupture of the liner, with consequent excessive leakage. The problem was considered to affect only some tyres of this type; the manufacturers concluded that the defect was likely to have been responsible for some of the previous failures experienced by the operator. Use of this type of tyre on the 757-300 was discontinued in February 2001 and production of the tyre was stopped. The tyre manufacturer developed an improved, new Part Number version (040-800-1) which was certificated and made available in March 2001.

The fusible plugs fitted to Wheels 7 and 8 were of a type that had reportedly been used by the wheel manufacturer for around 30 years. No problems of loss of torque in service had been experienced until a year or so before 4X-BAU's accident, when a number of such reports had been received by the wheel and aircraft manufacturers. A BF Goodrich Aerospace Service Letter (BFG SL 1805, issued 2 April 1999), applicable to the B737-600, -700, -800 and Boeing Business Jet (BBJ) aircraft, noted that 'Three operators have reported that low tyre pressure has caused early removal of some wheel assemblies, P/N 3-1558. All of these wheel assemblies had experienced a low number of landings. Examination has shown that the pressure loss was caused by loose thermal relief plugs.' It informed that the manufacturer was applying paint stripes to 'a specific quantity of new wheel assemblies' to provide visual indication of unscrewing of the plugs. It also gave a procedure, at each tyre change, to torque-check the plugs and, if desired, to reinstall the plugs with Loctite 222 or 242 applied to the threads. The procedure did not include the addition of paint stripe indicators by the overhauler. The Letter did not categorise or specifically recommend the procedure.

A BF Goodrich-Messier Service Letter (SL 1826, issued November 1999), applicable to the Airbus A340, noted that 'Some operators have reported loss of tyre pressure due to loose thermal relief plugs.' It recommended the application of Loctite to the threads of fusible plugs at the next workshop visit. The above cases concerned wheels generally similar to those fitted to 4X-BAU, but with the fusible plugs installed in the wheel tubewell, rather than in the thick section between the wheel tie bolts.

Post-accident checks on 98 BF Goodrich 757-300 MLG wheels, initiated by the aircraft manufacturer, found one loose inflation valve in one wheel and one loose fusible plug in another.

Follow up action

Following the accident to 4X-BAU, the aircraft manufacturer and the operator undertook a review of the previous failures and of tyre maintenance practices, in view of the appreciable rate of tyre failures. It was concluded that all the failures had resulted from the effects of over deflection and/or under inflation caused by leaky wheel/tyre assemblies. Some evidence suggested that the damaging effects of operating with appreciably under inflated tyres, both on the under inflated tyre and on its partner on the same axle had not been appreciated and that in some cases specified action may not have been taken where pressures below the minimum had been found

The typical aircraft tyre/wheel assembly has approximately 12 potential leak paths and information from tyre manufacturers indicates that a pressure loss of up to 5% / 24 hours can be considered normal. A general theme among the manufacturers is that 'keeping aircraft tyres at their correct inflation pressure is the most important factor in any preventative maintenance programme'. Testing has shown the following general characteristic of the effect of under inflation on the number of test take-off cycles before failure of a typical aircraft tyre. Furthermore an under inflated condition to a lesser or greater extent, of one tyre on a landing gear with dual wheels on an axle, would probably not be detectable by visual checks as the fully inflated tyre would take the load and prevent abnormal flattening of the under inflated tyre.

Discussion

The evidence showed that both right MLG aft tyres failed within a few seconds of each other shortly after aircraft touchdown. The signs of somewhat higher speed debris from Tyre 8 than Tyre 7 suggested that Tyre 8 probably was the first to fail. No evidence was found to indicate that the failed tyres were defective when fitted but the possibility could not be dismissed in view of the high level of roll-flat damage. The investigation found that Tyre 8 had suffered somewhat more damage than Tyre 7 and in particular showed appreciably greater overheat effects. Overheating is likely to result from excessive deflection while rotating, with excessive cyclical flexing of the sidewall fabric causing heat generation and the resultant temperature increase leading to a reduction in cord strength. Accelerated fatigue of the fabric can result. Excessive deflection would have been the result of operating while the tyre was either underinflated or overloaded. The most likely cause of Tyre 8 overloading would be under inflation of Tyre 7. Thus it was concluded that the accident had probably been caused by operating with either Tyre 7 or Tyre 8 underinflated. It was possible that either or both of the tyres had previously been damaged by an earlier episode of operating while underinflated or with an underinflated partner.

The reasons for underinflated operation could not be determined as there was no record of significant pressure loss having been found since the tyres had been installed. However, tyre pressures were not routinely recorded. The possibility that the FOD penetration of the outer parts of Tyre 7 that was found had in fact penetrated the liner and caused a pressure loss could not be dismissed. It was also possible that the tyre design/manufacture problem identified after a further failure in early 2001 may have been present and have caused a pressure loss. The loose fusible plugs found in Wheel 8 were a possible cause of pressure loss from the tyre fitted to this wheel. While no abnormal leakage occurred during the pressurisation check carried out in the course of the investigation, this was conducted at room temperature and it was possible that temperature variations experienced by the wheel when installed on the aircraft could have affected the sealing ability of the plug seals.

The reasons for the loose fusible plugs were not established. The similarity between their condition suggested a build procedural problem that had led to omission of the torque-tightening operation. However, they are not mechanically locked and the possibility that they had loosened in service could not be totally dismissed. While such a problem with the plug type reportedly had not been encountered over many years, recent cases of loosening in other wheel types had occurred, for reasons that the wheel manufacturer was still attempting to identify. Additionally, a further case of a loose fusible plug in another B757-300 wheel was found. In view of this background the following recommendation is made:

Safety recommendation 2002-13

It is recommended that BF Goodrich Aerospace comprehensively reassess their measures aimed at ensuring that aircraft wheel fusible plugs are correctly tightened and do not loosen in service, consider the need for positive locking of all plugs and valves and revise their requirements as necessary.

The evidence indicated that underinflated operation is particularly damaging to aircraft tyres and the most likely cause of tyre break-up, either directly or indirectly. A significant amount of kinetic energy is present in the tread and carcass of a tyre rotating at high speed and detached tyre debris has the potential for causing aircraft damage. In this case the damage did not noticeably affect the operation of the aircraft but was widespread and potentially serious damage to the brake systems occurred and debris had come close to an engine intake. In other known cases however extensive flap damage, hydraulic system loss and/or engine damage and sudden engine failure at a critical point during take-off have occurred (ie Concorde F-BTSC at Paris Charles de Gaulle on 25 July 2000 (Bureau Enquetes Accident Report f-sc000725)).

While tyres are routinely examined as part of the flight crew's preflight check it is known that even gross underinflation of a single tyre on a multi-wheel assembly is difficult or impossible to detect by visual examination of the tyre. It is therefore possible for the tyres to be to run while severely underinflated and thus in a hazardous condition during the interval between scheduled checks unless an indication system is provided. Wheel-mounted pressure gauges (See Figure 1) provide a relatively simple and reliable means of indicating tyre pressure visible to crews before flight. More comprehensive coverage would be provided by a TPIS system, which is available, but is not generally a requirement, as an optional extra for many modern aircraft.

In the course of a previous accident investigation (BAC 1-11 registration G-AWYR at Birmingham Airport, UK, on 21 November 1997, AAIB Bulletin 4-99) the following AAIB Safety Recommendations were made:

> **Safety recommendation 99-11**: The CAA consider a requirement for the installation, on the wheels of UK registered aircraft where a potentially hazardous level of tyre underinflation can be undetectable by external visual inspection, of a device to provide ready indication of such a condition during routine pre-flight external inspection.
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> **Safety recommendation 99-12**: The CAA consider requiring the fitment on future aircraft types on the UK Register of a system to provide continuous flight deck indication of tyre pressures and/or warning of abnormal pressures.

The CAA response, made in December 1999, stated that they accepted both recommendations and would 'consider the need for such a requirement by conducting a review, which is intended to be completed by 31 December 1999.'

Subsequent inquiries showed that the CAA completed a review of service history in May 2000 and concluded "This review has indicated that the tyre low pressure condition alone is not responsible for a significant proportion of the tyre failure incidents, therefore a tyre low pressure indication device, capable of interpretation during routine pre-flight inspection, would be of limited benefit and would not lead to a significant reduction in the number of tyre failures. The Authority therefore considers that this review has confirmed that current design requirements are adequate in minimising the hazards associated with a tyre failure or tread release."

The potential hazard of operating with underinflated tyres and the common difficulty or impossibility of detecting even gross underinflation without a continuous indication system has again however been demonstrated by this accident. In view of this the following recommendation is made:

Safety recommendation 2002-14

It is recommended that Airworthiness Authorities such as the JAA and FAA consider implementing the measures outlined in AAIB Safety Recommendations 99-11 and 99-12 concerning requirements for tyre pressure monitoring and warning systems.