Airbus Industrie A300 B4, EI-TLL

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Aircraft Type and Registration:	Airbus Industrie A300 B4, EI-TLL
No & Type of Engines:	2 General Electric CF6-50C2 turbofan engines
Year of Manufacture:	1981
Date & Time (UTC):	17 July 1997 at 1540 hrs
Location:	Manchester International Airport
Type of Flight:	Public Transport (passenger)
Persons on Board:	Crew - 12 - Passengers - 46
Injuries:	Crew - None - Passengers - None
Nature of Damage:	Damage to left main landing gear, hydraulic lines and components
Commander's Licence:	N/K
Commander's Age:	N/K
Commander's Flying Experience:	Last 90 days - N/K
	Last 28 days - N/K
Information Source:	AAIB Field Investigation

Approximately 90 minutes after an apparently normal take off from Faro Airport, Portugal, the Captain of EI-TLL was informed that a piece of landing gear bogie, identified as a brake unit anti-rotation bar from his aircraft, had been found on the runway at Faro. The flight was continued to Manchester where, following a 'fly-by' of the Control Tower it was reported that the landing gears appeared to be intact, although during the flight the crew noted that there had been some loss of yellow system hydraulic contents and No 6 brake anti-skid 'Release' light had not illuminated upon landing gear extension.

A Full Emergency was declared as the aircraft prepared to land and, upon touchdown, No 6 tyre burst and the remaining hydraulic fluid in yellow system was lost. The aircraft vacated the runway and came to a halt, where the left engine was shutdown to allow the fire service to approach. They reported that there was a lot of smoke from the left main landing gear but no signs of fire, so a bus and stairs were ordered to disembark the passengers. Subsequent inspection showed that, in addition to the burst No 6 tyre, No 1 brake anti-rotation bar was missing and the brake housing had rotated causing the inevitable damage to hydraulic lines and electrical wiring.

Description of the main landing gear

The A300 B4 aircraft uses a conventional 4-wheel bogie main landing gear arrangement. The wheels are numbered 1 to 4 from left to right across the front row of wheels and 5 to 8 across the back row. Thus the left bogie mounts wheel No's 1 and 2 at the front and 5 and 6 at the back. The brake housings are mounted on the axles and the torque of brake application is reacted by anti-rotation bars (see Figure 1). Each end of the anti-rotation bar locates on substantial steel pins, one on the brake and the other on the leg, which react the brake torque with a loading ideally purely in shear. A collar, with a bolt passing through it, retains the bar on each of the pins and it should be noted that, theoretically, the bolt and collar should not be subject to any high loading induced by braking (see Figure 2). Brake units for the aircraft were available from two vendors - B.F. Goodrich and Messier-Bugatti. EI-TLL had recently been fitted with the latter (see 'Maintenance History of EI-TLL' below).

EI-TLL, Manufacturers Serial Number 158, was an A300 B4 aircraft from a batch originally ordered by Eastern Airlines in the United States. A total of six of these aircraft were fitted with main landing gear bogies with a slightly wider track in order to satisfy particular taxiway loading requirements at La Guardia Airport, New York. Hence it is commonly referred-to as 'The La Guardia Bogie' and differs slightly in axle length and in the geometry of the anti-rotation bars. Four of the six aircraft are currently operating in Pakistan whilst the other two, EI-TLL and EI-TLK, are registered in Eire.

In other respects, EI-TLL is similar to other aircraft of the same series including the braking/hydraulic systems. Green hydraulic system powers Normal brakes and Yellow system powers Alternate brakes. Both Normal and Alternate braking feature an anti-skid system which uses nosewheel speed as its reference. Normal braking is signalled electrically, whilst the Alternate system uses conventional hydraulic cylinders at the pedals to modulate the brake pressure. When gear is selected DOWN prior to landing, eight small captions should illuminate on the Anti-skid Control Panel to show that the anti-skid system is signalling full release to all eight wheels.

Examination of components

The No 1 brake anti-rotation bar was recovered from the runway at Faro together with the retaining collars and pieces of the bolts. It is not known where on the runway they had been found. Initially, the bolts were sent to Aerospatiale laboratories for examination and then subsequently to AAIB, who also asked the Maintenance company for the other retaining bolts from the same bogie.

The anti-rotation bar itself was intact and undamaged apart from scraping due to runway contact. The holes in the retaining collars through which the bolts passed were distorted in compression due to excessive loads exerted by the bolts in a direction consistent with the bar moving laterally with respect to the aircraft centreline. When later obtained from Aerospatiale, the remains of the bolts which secured the collars showed clear evidence of shear failures caused by a very small number (possibly less than 10) of very high load reversals.

As mentioned above, the bolts from the other brakes were requested from the Maintenance organisation but in fact only four were received. Two of these were marked as coming from brakes 2 and 5 and the other two were not identified. The No 2 brake bolt appeared, from its dimensions, to come from the brake end of the rod and that from No 5 from the leg end. The two unidentified bolts appeared both to be from the brake ends, presumably from Nos 5 and 6. Whilst all the bolts examined showed signs of fretting corrosion on the shanks, the bolt identified as coming from No 2 brake had been plastically deformed in shear at the points where it passed through the retaining collar. All the bolts met the minimum hardness requirements specified by the manufacturer.

The Brake and Steering Control Unit (BSCU) was removed from the aircraft and despatched to its manufacturer for testing. Their report stated that two cards were found to be defective and analysis showed that the first defect could lead to a loss of braking efficiency for wheels 1 and 4 whilst the other could have caused locked wheel or hot brake conditions on wheels 5 and 8.

The landing gear itself was thoroughly checked for wear in components and also for correct incorporation of the brake Service Bulletin ('Maintenance History' below). No defects were found.

Previous cases of anti-rotation bar detachment

According to Airbus Industrie, the incident involving EI-TLL was the second case of anti-rotation bar detachment involving an A300 aircraft. A third incident took place in April 1998. Significantly, all the incidents involved aircraft fitted with the 'La Guardia bogie' and Messier-Bugatti brakes. It was stated that the first case, in December 1996 in Pakistan, had not been investigated in depth as the landing gear concerned had just been fitted to the aircraft and it had been assumed that the retaining bolts had not been properly installed. However, the 1998 incident was to the *same* aircraft in the *same* brake position (No 2 brake) and it was found that No 6 wheel had locked and the tyre had burst and that No 2 brake had partially seized. As was the case with EI-TLL, the aircraft had been troubled with brake problems on the left MLG at the time of the incidents and in both cases the anti-rotation bar had detached in a manner similar to the one described above.

Maintenance history of EI-TLL

Before operation by the current airline, EI-TLL had been in storage for some time and had undergone a 'D' check in May/June 1997, during which time Airbus Service Bulletin 470-32-677 was incorporated which changed the brake units from B F Goodrich type to Messier-Bugatti.

The technical records showed that the aircraft's first flight after the check occurred on 22 June but no entries in the Technical Log were made concerning brakes until 1 July when No 5 mainwheel tyre burst "during aircraft loading". A flat spot on the tyre, indicative of a locked-wheel condition, was found to be responsible. No's 5 and 6 mainwheels were changed at this time after a check in accordance with the Maintenance Manual found no defects but the No 5 brake was de-activated "for sufficient time to trouble-shoot" and an Acceptable Deferred Defect (ADD) entry was made. Two sectors later, on the following day, No 5 brake was re-activated and then de-activated "as a precautionary measure for trouble-shooting". No further brake problems were mentioned until 6 July when it was reported that No 2 brake was "grinding" at taxi speeds when it was applied. The axle was jacked-up and the wheel found to spin freely, thus no further action was taken.

On 17 July, in order to close the ADD on No 5 brake, the anti-skid control valve was changed but the ADD remained open as No 5 brake was not re-activated "awaiting further maintenance action and function checks". This accident occurred the same day and thus the aircraft was still operating with No 5 brake inoperative.

Examination of the Aircraft's history pre-storage in 1993, when it was being operated in Turkey, showed a Technical Log entry for abnormal brake temperatures on wheel No's 1 and 5 followed by a fusible plug deflation of No 5 wheel tyre. A few maintenance entries recorded the exchange of the BSCU for that from another aircraft before the Log ends in October 1993. There was no indication as to whether the problem was resolved but in August an entry for the No 5 anti-skid RELEASE light illuminating during landing and taxi was recorded. Some words in the 'Corrective Action' column in Turkish ended with "Test OK".

After the aircraft was repaired and returned to service, the list of Technical Log entries concerning brake problems with the left MLG continued and multiplied. Up to 19 June 1998, there were some eight entries against No 6 brake for running abnormally cool, one for the tyre found deflated (fusible plugs melted) and one for the brake being visibly overheated and damaged. No 2 brake had two entries for being found locked, two for tyre bursts, two for running abnormally hot and one for running abnormally cold. Brake No 1 had two entries - one for running hot and one for being found seized. Rectification attempts have included de-activating brakes, exchanging or replacing anti-skid components, inspections and recording brake temperatures. At the time of preparation of this Bulletin it is understood that the aircraft is still experiencing similar problems but specialists from Airbus Industrie are working with the operator to try and resolve the situation.

It has been reported that, on one occasion whilst the aircraft was based abroad in 1998, deformed anti-rotation bar retaining bolts were discovered during a brake change. Information is somewhat sketchy regarding this discovery but circumstantially it probably took place in North Africa when the Technical Log for 14 April 1998 recorded the No 1 brake seizure and subsequent change.

Discussion

Airbus Industrie advise that the only known cases of A300B anti-rotation bar detachment such as this are those described above. The Boeing 767 aircraft, which used a broadly similar arrangement for retaining its anti-rotation bars also has some history of failures of the retaining hardware and, more recently, a failure of the bar itself. Some considerable testing has been done on the latter aircraft and modifications/inspections mandated but both types involved share the same feature inasmuch as components (ie the retaining hardware) which should theoretically be experiencing minimal loading were seeing significant loads and therefore failing.

Generation of such loading can only occur with lateral loads applied to the bar caused by either distortion of the leg/bogie/brake assembly, gross wear in these components or a combination of both. In the case of the Boeing 767, the anti-rotation bar separations have only occurred on carbon-brake equipped aircraft. It is suspected that the particular characteristics of such brakes, possibly combined with anti-skid system performance, can generate high transient asymmetric braking forces on a 4-wheel bogie system with consequent structural distortion. This problem is being addressed at Boeing by the introduction of a new carbon material.

EI-TLL did not have carbon brakes but did, and it appears continued to have, a history of locked wheels and hot brakes which, at the time of writing, has defied normal troubleshooting methods. It is not difficult to envisage that, if a faulty brake or anti-skid system was to suddenly apply a large amount of pressure sufficient to cause a locked wheel whilst the others are operating normally or possibly with minimal braking action demanded, the asymmetric application could cause structural deflections to the bogie. This could have been further exacerbated by the fact that the aircraft was operating with the No 5 brake de-activated.

The failure of the bar retaining bolts apparently occurred whilst the aircraft was on the runway, if reports that both the bolts, collars and the bar itself were found together in that location are correct. The probability that failure of the bolts and detachment of the bar was simultaneous (as opposed to the failure occurring at an earlier time and the bar detaching later due to its migration off the locating pins) is given further credence by the fact that it is not possible, with the brake fitted, for the bar to come off the pins. Gross distortion of the leg/bogie geometry is necessary to achieve this, indeed to such an extent that the manufacturer's technical staff had difficulty in believing that such distortion could take place. However, the three incidents demonstrate that forces acting on the bogie can and do cause very severe geometry changes. It is probable that the wider track of the 'La Guardia bogie' serves to amplify the torsional effect caused by asymmetric brake application, which is why the only incidents of anti-rotation bar detachment have involved aircraft fitted with this configuration.

Of some concern must be the failure to resolve the on-going history of problems with the left brakes, which would be serious even if it did not result in anti-rotation bar detachment. The nature of the problems is very confusing, as they seem to have affected all the brakes on the left MLG at different times and apparently vary from abnormally high to abnormally low application of one or more brakes. The problem is further complicated by its intermittency and by the itinerant nature of EI-TLL's operation. Essentially operating a series of short-term wet leases, it is a fact of life that in-depth troubleshooting at base is likely to take second place to the shorter-term expediency of keeping the aircraft operating. There is also the problem of continuity when an aircraft operates from a different 'base' almost every day and rectification work is carried out on an ad hoc arrangement. It is anticipated that, with the manufacturer actively involved, long overdue resolution of the defects affecting the aircraft's left braking system can be achieved.