# ATR72-202, G-BWTM

## AAIB Bulletin No: 11/99 Ref: EW/C99/2/2 Category: 1.1

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| **Aircraft Type and Registration:** | ATR72-202, G-BWTM |
| **No & Type of Engines:** | 2 Pratt & Whitney PW-124B turboprop engines |
| **Year of Manufacture:** | 1995 |
| **Date & Time (UTC):** | 10 February 1999 at 1620 hrs |
| **Location:** | London Gatwick Airport |
| **Type of Flight:** | Public Transport |
| **Persons on Board:** | Crew - 4 - Passengers - 17 |
| **Injuries:** | Crew - None - Passengers - None |
| **Nature of Damage:** | Damage to nose landing gear |
| **Commander's Licence:** | Airline Transport Pilot's Licence |
| **Commander's Age:** | 24 years |
| **Commander's Flying Experience:** | 2,500 hours (of which 1,200 were on type) |
| | Last 90 days - 160 hours |
| | Last 28 days - 70 hours |
| **Information Source:** | AAIB Field Investigation |

**History of the flight**

Following a normal pre-flight check and taxi to the runway for a flight to Rotterdam, the crew had noted that momentarily before rotating during take off a 'shimmy sound' was heard. In the absence of any other indications of a problem, the flight continued to Rotterdam. However after an uneventful landing, it was discovered that the right nosewheel and the outboard section of the right nosewheel axle were missing. The subject wheel, containing the missing section of axle, was subsequently found at Gatwick Airport.

**Nosewheel description**

The nosewheel hubs on the ATR72 are of conventional design, with two forged aluminium halves bolted together, in this case with five bolts, as illustrated in Figure 1. There is a taper roller bearing installed within each half hub, the outer race of which is a tight fit within its housing. The inner race is a close fit on the steel axle such that it may be slid on and off, but with minimal radial clearance between the two. Whenever a wheel is installed, an axial pre-load is applied to both bearings by a wheel axle nut screwed onto the end of the axle and which abuts against the inner race of the outer bearing. These axial loads are reacted by the inner race of the inboard bearing against a sleeve fitted around the inboard section of the axle. Thus the inner races resist rotation by means of the frictional forces resulting from the axial pre-load.

The relevant Aircraft Maintenance Manual (AMM) detailed the method by which the axle nut should be fitted and required that when installing a wheel assembly the nut should be initially tightened to a torque of 360 lbf in, whilst rotating the wheel. The torque should then be 'backed off' to zero, ensuring that all components remain seated, and then re-applied to its final value of 120 lbf in, again whilst rotating the wheel. Should the nut not then be at a locking position, it is permitted to advance the castellated nut until one of its slots aligns with the next hole in the axle. The axle nut is then locked by a small locking bolt which passes through the aligned slot and hole, and which itself is secured by a small castellated nut and cotter pin.

**Examination of nose landing gear**

The nose landing gear was replaced in Rotterdam and the components returned for examination by the AAIB. The left nosewheel and left axle appeared to be undamaged and the axle nut was present together with the locking bolt, nut and reportedly, when first seen by maintenance personnel, the associated cotter pin. The bearings in this wheel were well greased, free to turn smoothly and of normal appearance. The right wheel was complete, but both half hubs and the outer wheel bearing were obviously damaged. It was also apparent that all five hub bolts were loose, the nuts on three of these being found 'out of safety', ie with insufficient threaded portions protruding beyond the end of the nuts. The section of axle within the outer bearing could not be removed conventionally, but had to be pressed out, together with the bearing inner race, which was then separated. Examination of these components revealed clear evidence that the bearing inner race had spun on the axle, causing severe localised frictional heating. The axle had failed at the mid point of the bearing, but tacky grease was present on the bearing components, indicating that the heating had occurred for only a relatively short period of time. Metallurgical examination of the axle failure revealed no evidence of fatigue cracking, or other pre-existing defect, but indicated that the axle had failed from a mechanism known as 'liquid metal embrittlement'. This may occur whenever the protective plated layer (in this case cadmium plating around the bore of the axle) is heated to its melting point, or above. The liquid metal is then able to rapidly diffuse into the grain boundaries of the parent steel material in the heated area, resulting in weakening of the steel microstructure. The axle was then able to separate along these affected grain boundaries under relatively light loading.

The axle nut, as shown in Figure 1, was found jammed at the 'fully screwed in' position, with no alignment of any of the locking bolt holes in the axle with any slot in the castellated nut, and with no evidence of a locking bolt present. Close examination of the holes and slots revealed no evidence of damage that would have been consistent with an overload failure of a correctly installed locking bolt. It was thus concluded that at the time of the failure, a locking bolt had not been present. Without a locking bolt to restrain the nut, there would have been a tendency for the axle nut to tighten against the bearings over a period of time due to rotational drag forces on the inner race being transmitted to the nut by friction between the outboard end of the inner race and the mating face of the right hand threaded nut on the axle. Any significant increase in loading would have been likely to lead to a relatively sudden failure of the bearing, at which point the inner race would have spun on the axle. Any such rotation could have encouraged the axle nut to rotate and 'bottom out' on the thread, as found. By contrast, the inboard bearing of this wheel was examined and found to be well greased, with little evidence of distress. It is reasonably common, however, for bearings not to fail simultaneously under such conditions.

The maintenance records for the aircraft showed that both nosewheels had been replaced due to tyre wear some 10 days prior to the incident, in accordance with the AMM, section 32-42-00. On wheel re-build the bearing components had been kept as sets and it had been deemed that all four bearings were fit for further service at that time. Advice was sought from the wheel manufacturer as to the possible influence that the loose hub bolts could have had on the performance of the wheel bearings. The manufacturer's advice was that if the bolts had become loose in service, the wheel bearing loads would have increased by reacting the tyre inflation loads in addition to normal loading, but if the bolts had been loose prior to wheel fitment, then the inflation loading would have little effect. It was also considered likely that slight bearing misalignment under these circumstances would have reduced bearing life. However, due to the relatively short service life of the failed bearing since it was last inspected, it was considered unlikely by the wheel manufacturer that it would have failed solely due to the presence of loose hub bolts.

From the examination, it could not be positively determined why the locking bolt was missing from the axle. Since the wheels had been installed the aircraft had flown some 80 sectors, and each tyre had been subjected to a pressure check on 10 occasions during daily inspections. Since the tyre inflation valve is close to the axle nut, it seemed reasonably unlikely that the locking bolt had been missing for a period of time as this should have been readily apparent on these daily tyre pressure checks. The lack of any significant deformation on the axle nut or the axle locking bolt holes indicated that the locking bolt had not failed due to overload. It was therefore considered most likely that the cotter pin securing the small castellated nut to the locking bolt had either failed, or had not been installed, allowing the nut to unscrew and the bolt then to be released at some time shortly before the incident.