Accident

Aircraft Type and Registration:	ATR 72-212 A, G-CMJM
No & Type of Engines:	2 Pratt & Whitney Canada PW127M turboprop engines
Year of Manufacture:	2017 (Serial no: 1464)
Date & Time (UTC):	31 October 2023 at 0917 hrs
Location:	On departure from Edinburgh Airport
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 4 Passengers - 55
Injuries:	Crew - None Passengers - None
Nature of Damage:	Fractured nose landing gear axle
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	61 years
Commander's Flying Experience:	9,530 hours (of which 150 were on type) Last 90 days - 148 hours Last 28 days - 54 hours
Information Source:	AAIB Field Investigation

Synopsis

Whilst taking off from Edinburgh Airport the right wheel from the nose leg gear detached from the aircraft. The detachment was not observed by the airfield operations department and the flight crew were unaware of the loss of the wheel. They continued the flight and landed at Belfast City Airport without any abnormal indications or adverse aircraft performance. The wheel was first noticed missing as the aircraft taxied onto stand at Belfast. A failure of the wheel axle caused by bearing overheat was identified as the cause of the wheel detachment. A number of potential contributing factors were identified, but the cause of the bearing overheat could not be positively determined.

History of the flight

On its return flight from Edinburgh Airport (Edinburgh), the aircraft performed an ILS approach and landing on Runway 04 (Rwy 04) at Belfast City Airport (Belfast). The flight crew reported that everything appeared normal until after the aircraft had parked, when the ground crew informed the commander that a nosewheel was missing.

After the commander informed ATC, both airports carried out runway inspections, and local police searched the area under the approach path. The nosewheel was found beside the runway at Edinburgh.

The flight crew and Edinburgh ground crew reported noticing nothing unusual about the aircraft during its turnaround in Edinburgh.

Accident site

Edinburgh Airport

The nosewheel separated from the aircraft during takeoff from Edinburgh Runway 06 (Rwy 06) (Figure 1). It would not have been easily visible to persons in the control tower and was evident on the surface movement radar for only a couple of seconds before traversing off the side of the runway.

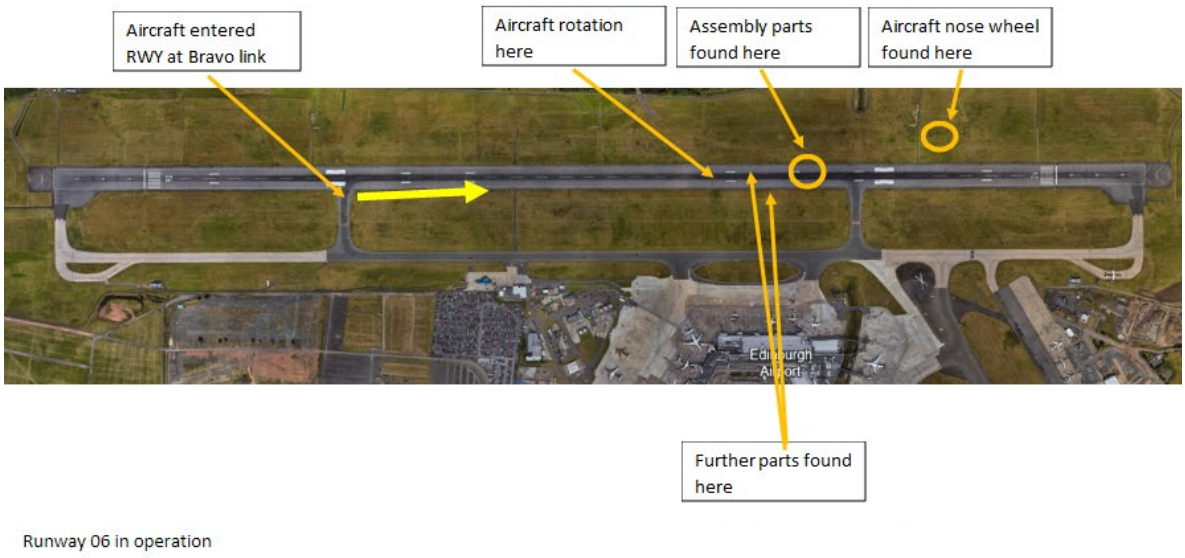

Figure 1

Location of recovered nosewheel components

All components related to the detached nosewheel including the wheel axle nut were recovered. The locations at which the detached components were found at Edinburgh are as shown (Figure 1). There was no damage to the airport infrastructure reported.

Belfast Airport

Following an ILS approach (which overflies the city of Belfast) to Rwy 04, the aircraft taxied uneventfully to its normal operational stand. Whilst the aircraft remained stable, additional support was provided to the nosewheel to provide increased support against the wind (Figure 2).

Figure 2

The aircraft as quarantined at Belfast City Airport

Aircraft examination

The nose leg gear axle was sheared off and showed evidence of heat damage (Figure 3). Extensive checks of the aircraft nose landing gear bay showed no signs of other damage or fluid leakage. A detailed inspection of the aircraft structure and engines revealed no damage due to the release of the nosewheel. There was no hard landing or abnormal runway contact reported by flight crews during the flight when the wheel was lost or on previous flights.

Figure 3

G-CMJM fractured nose landing gear axle

Aircraft information

The aircraft had the nose landing wheels changed by the line maintenance organisation on 11 October 2023 as part of a standard work package. There were no issues reported with the nose landing gear (NLG) in the sectors prior to the accident flight.

Further tests and research

The nosewheel, the other associated components recovered from Edinburgh and the NLG shock assembly were sent to the manufacturer for further inspection and analysis.

Inspection of NLG wheel assemblies

Right NLG Wheel

Design of the NLG wheel assembly P/N C20589000:

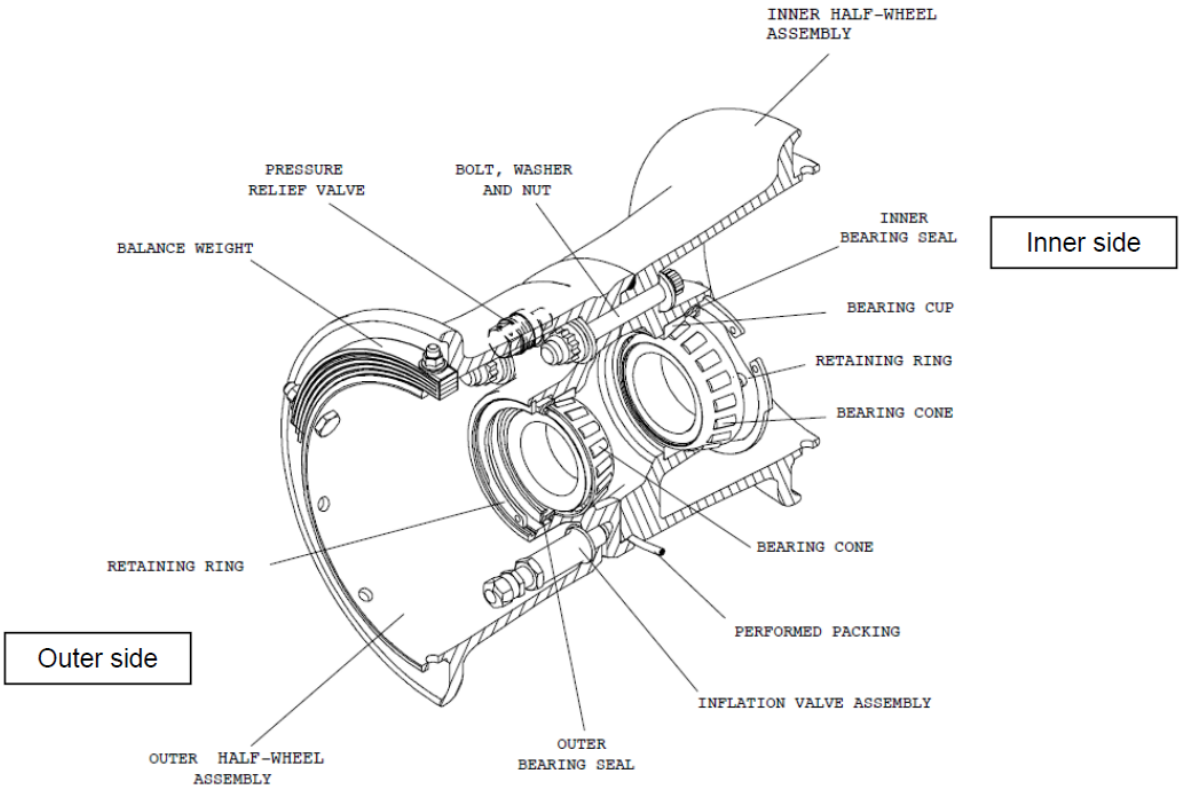

Figure 4

Design of the NLG wheel assembly (Image used with permission)

The right NLG wheel (design shown at Figure 4) was inspected and dissembled with the following main findings:

- The right NLG wheel assembly was found assembled with all tie bolts loose.
- No balancing weights were found fitted on either the outer or inner half-wheel sections[1].
- The outer half wheel hub was found fractured.
- There was an interposition product found on the mating faces of the two half-wheels (Figure 5); this product is not allowed in this area[2] as it can lead to micro displacements of the two faces and tie-bolt loosening.
- Evidence of bearing grease indicated over-greasing of both bearings.

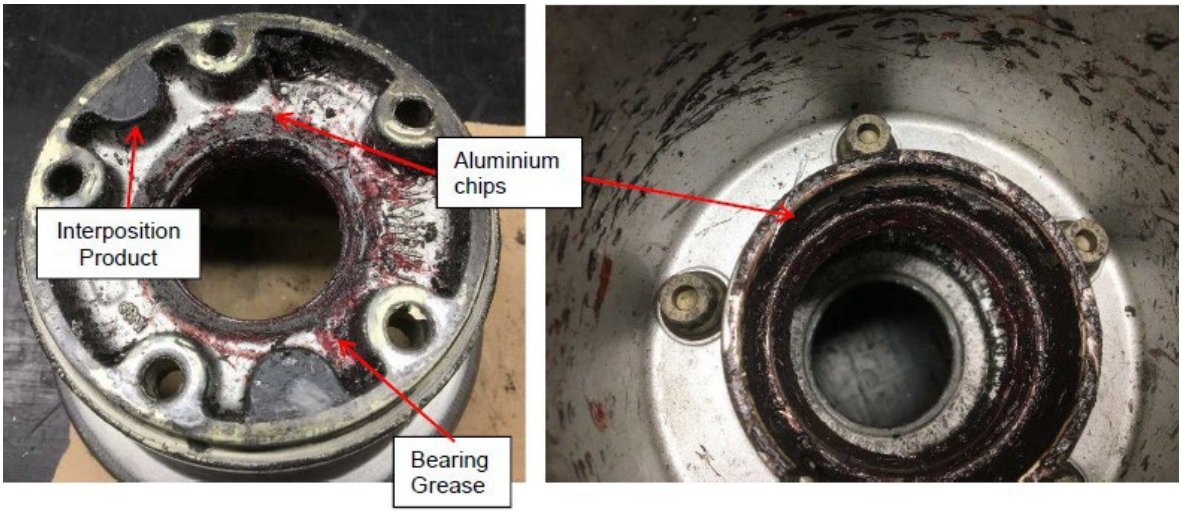

Figure 5

Inner half wheel condition (image used with permission)

- Outer bearing assembly. The outer bearing assembly cone was completely deformed due to the heat generated during the bearing failure (Figure 6). The cage, outer bearing seal and retaining ring were missing. There was evidence of material transfer on the internal diameter and only one roller, which was damaged, was present.

Footnote

[1] Component Maintenance Manual reference CMM 32-49-43 states the weights are not installed if the remaining imbalance is not more than 7,35 g.m (10.4 oz.in).

[2] The manufacturer advised that this interposition product should only be used on mainwheels not nosewheels as per CMM 32-49-43.

Figure 6

Outer bearing cone heat damage (image used with permission)

- Inner bearing assembly. The rollers, cage, circlip, grease and seal were all missing due to the heat damage. Roller marks were observed on the bearing race (Figure 7), which is an indication that the rollers were not aligned properly.

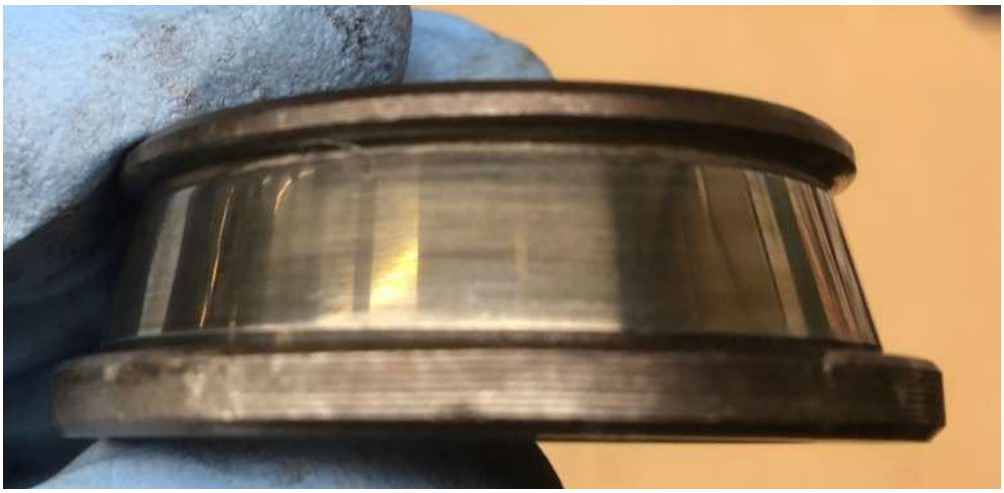

Figure 7

Inner bearing cone circumferential marks (image used with permission)

Left NLG Wheel

The left NLG wheel assembly was inspected and all the tie bolts holding the half-wheels together were found loose. An interposition product was found between the two half-wheels, and the balancing weights were not fitted on the NLG wheel. The bearings (Figure 8) were in better condition but also showed signs of over greasing and heat damage.

Figure 8

LH NLG wheel bearing (image used with permission)

Metallurgy

Inspection of the failed components indicated exposure to high temperatures which were consistent with a wheel bearing failure event. Laboratory analysis for the failed axle did not identify the precise region of crack initiation but the metallurgical analysis of the axle indicated that the thermal shock and evidence of cadmium liquid metal embrittlement both likely contributed to the complete fracture of the axle.

Bearing overheat causes

Whilst it was not possible to identify one single cause of the bearing overheat and subsequent failure, the manufacturer of the NLG highlighted a number of factors that can contribute. These factors can occur during aircraft line maintenance or at component Maintenance Repair Organisations (MRO) and are grouped below:

- Aircraft Line Maintenance
  - An incorrect bearing preload (preload obtained by the tightening of the NLG wheel axle nut).
  - An incorrect bearing installation (which can be caused by an improper torque operation (wheel not rotated) allowing rollers to move radially).
  - A misalignment of the rollers, which causes roller metal fracture and discoloration, as well as cage wear and rupture.
- MRO Component Overhaul
  - Incorrect lubrication on the inner and outer bearings.
  - The presence of an interposition product between the two half-wheels, which is not allowed on this area for the NLG wheels, which has an impact on the tightening and could lead to the tie bolts becoming loose.
  - The lack of wheel balancing weights, which can lead to a misalignment of the real rotation axis of the bearing. This can lead to damage of the rollers and then contribute to a bearing failure.

Maintenance practice

As well as the Aircraft Maintenance Manual (AMM) and Component Maintenance Manual (CMM) procedures, the manufacturer of the NLG issues advice on the management of the wheel assembly and bearings to maintainers via its support portal. The manufacturer of the NLG also conducts visits with MROs that overhaul wheels to discuss good maintenance practices and had, together with the Operator, visited the MRO that overhauled the nosewheels on G-CMJM prior to the accident, and they carried out a follow up visit in May 2024.

Analysis

Operations

There were no indications to the flight crew during the flight that the nosewheel had detached from the aircraft, and it was not easily detectable in Edinburgh because it came to rest away from the runway surface. Communications by airport staff meant any debris was located promptly.

Aside from risks inherent to debris on active runways, had the nosewheel detached during the approach at Belfast, it could have fallen on an urban area.

Cause of the wheel loss

The right NLG wheel detached from the aircraft because the axle on which it is located fractured. The axle fractured due to overheating of the bearing in the wheel which caused a combination of thermal shock and liquid cadmium embrittlement. The cause of the bearing overheating could not be positively determined, but inspection of the failed components identified a number of factors that could have contributed. These included over greasing of the inner and outer bearings, the lack of wheel balancing weights and the application of an interposition product between the mating faces of the two half-wheels which can cause the tie bolts to loosen. The manufacturer of the nose leg gear assembly highlighted the importance of adherence to the AMM and CMM by aircraft maintainers and component repair/maintenance facilities respectively to ensure safety. As well as providing access to the aircraft and component technical publications for wheels and brakes on the ATR 72, the manufacturer's maintenance portal also contains in-service experience advice for operators and MROs.

Conclusion

The right NLG wheel detached from the aircraft on takeoff due to a failure of the axle onto which the wheel was located. The axle failed due to a fracture caused by overheat of the bearings in the wheel. Whilst the root cause of the failure could not be positively determined, factors were identified that could have contributed to the bearing overheat resulting from non-conformances with approved maintenance procedures. The manufacturer highlighted the importance of adherence to aircraft and component maintenance manuals.