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NATIONAL TRANSPORTATION SAFETY COMMITTEE

Aircraft Serious Incident Investigation Report

PT. Garuda Indonesia
PK – GGQ
Boeing Company 737-300
Soekarno – Hatta Airport, Jakarta
Republic of Indonesia

30 October 2009

NATIONAL TRANSPORTATION SAFETY COMMITTEE
MINISTRY OF TRANSPORTATION
REPUBLIC OF INDONESIA
2010

This Report was produced by the National Transportation Safety Committee (NTSC), Karya Building 7th Floor Ministry of Transportation, Jalan Medan Merdeka Barat No. 8 JKT 10110, Indonesia.

The report is based upon the investigation carried out by the NTSC in accordance with Annex 13 to the Convention on International Civil Aviation, Aviation Act (UU No.1/2009), and Government Regulation (PP No. 3/2001).

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GLOSSARY OF ABBREVIATIONS

AD	Airworthiness Directive
AFM	Airplane Flight Manual
AGL	Above Ground Level
ALAR	Approach-and-landing Accident Reduction
AMSL	Above Mean Sea Level
AOC	Air Operator Certificate
ATC	Air Traffic Control
ATPL	Air Transport Pilot License
ATS	Air Traffic Service
ATSB	Australian Transport Safety Bureau
Avsec	Aviation Security
BMG	Badan Meterologi dan Geofisika
BOM	Basic Operation Manual
°C	Degrees Celsius
CAMP	Continuous Airworthiness Maintenance Program
CASO	Civil Aviation Safety Officer
CASR	Civil Aviation Safety Regulation
CPL	Commercial Pilot License
COM	Company Operation Manual
CRM	Cockpit Recourses Management
CSN	Cycles Since New
CVR	Cockpit Voice Recorder
DFDAU	Digital Flight Data Acquisition Unit
DGCA	Directorate General of Civil Aviation
DME	Distance Measuring Equipment
EEPROM	Electrically Erasable Programmable Read Only Memory
EFIS	Electronic Flight Instrument System
EGT	Exhaust Gas Temperature
EIS	Engine Indicating System
FL	Flight Level
F/O	First officer or Co-pilot
FDR	Flight Data Recorder
FOQA	Flight Operation Quality Assurance
GPWS	Ground Proximity Warning System
hPa	Hectopascals
ICAO	International Civil Aviation Organization

IFR	Instrument Flight Rules
IIC	Investigator in Charge
ILS	Instrument Landing System
Kg	Kilogram(s)
Km	Kilometer(s)
Kt	Knots (NM/hour)
Mm	Millimeter(s)
MTOW	Maximum Take-off Weight
NM	Nautical mile(s)
KNKT / NTSC	Komite Nasional Keselamatan Transportasi / National Transportation Safety Committee
PIC	Pilot in Command
QFE	Height above aerodrome elevation (or runway threshold elevation) based on local station pressure
QNH	Altitude above mean sea level based on local station pressure
RESA	Runway End Safety Area
RPM	Revolution Per Minute
SCT	Scattered
S/N	Serial Number
SSCVR	Solid State Cockpit Voice Recorder
SSFDR	Solid State Flight Data Recorder
TS/RA	Thunderstorm and rain
TAF	Terminal Aerodrome Forecast
TSN	Time Since New
TT/TD	Ambient Temperature/Dew Point
TTIS	Total Time in Service
UTC	Coordinated Universal Time
VFR	Visual Flight Rules
VMC	Visual Meteorological Conditions

SYNOPSIS

On 30 October 2009, a Boeing Company 737-300 aircraft, operated by Garuda Indonesia as flight GA142, registered PK-GGQ, was being flown on a scheduled passenger service from Soekarno–Hatta Airport, Jakarta to Sultan Iskandar Muda Airport, Banda Aceh, via Polonia Airport, Medan. There were 55 persons on board; two pilots, four flight attendants, and 49 passengers.

The aircraft took off from Jakarta runway 07L at 0129 UTC. During the takeoff the number-two wheel separated from its axle and fell from the aircraft onto the runway. The air traffic controller subsequently informed the crew that one of the aircraft's main wheels had fallen from the aircraft onto the runway during the takeoff. The pilot in command (PIC) decided to return to Jakarta. The controller informed the airport rescue and fire fighting service (RFFS), and RFFS personnel and vehicles stood by during the landing.

The PIC taxied the aircraft off the runway and stopped it on taxiway NP1. The passengers disembarked normally via airstairs about 15 minutes after the landing. The RFFS crews were standing by the aircraft in case of a fire. None of the aircraft's occupants were injured.

The investigation determined that it was likely that the detachment of the number-two main wheel from its axle was due to the catastrophic failure of the wheel bearings. The bearing failures would then have resulted from an under-torque condition during the re-installation of the number-two main wheel, following the replacement of the brake unit.

The recent main wheel installation was conducted on the airport apron during the hours of darkness, and flash lights were used to illuminate the work. The work environment was not conducive to ensuring that the work could be performed safely and in accordance with approved procedures.

On 6 November 2009, PT. Garuda Indonesia informed the National Transportation Safety Committee that PT. GMF AeroAsia had commenced a number of safety actions to address safety concerns arising from this serious incident, including: a Quality Assurance Reminder drawing engineers' attention to specific maintenance quality and safety requirements; a scheduled retraining program for engineers involved in wheel and brake replacement to be completed by 19 February 2010; and on 6 and 10 November issued Engineer Orders for Main Gear Wheel Axle Nut Torque Check and Bearing Inspection to be completed by 30 November 2009.

The National Transportation Safety Committee issued recommendations to PT. GMF AeroAsia, PT. Garuda Indonesia, and the Directorate General of Civil Aviation, with respect to reviewing maintenance guidance documentation, training and supervision to ensure that correct practices are followed, and an appropriate maintenance environment is available.

On 23 December 2009, PT. GMF AeroAsia submitted a Customer Originated Change to the Boeing Company requesting an amendment to the wheel nut torquing procedures for Boeing 737 aircraft. PT. GMF AeroAsia also issued an Engineering Information document to its engineers detailing interim procedures pending the issuance of the Boeing amendment to the Boeing 737-345 Aircraft Maintenance Manual, which Boeing has indicated will be promulgated in September 2010.

1 FACTUAL DATA

1.1 HISTORY OF THE FLIGHT

On 30 October 2009, a Boeing Company 737-300 aircraft, operated by Garuda Indonesia as flight GA142, registered PK-GGQ, was being flown on a scheduled passenger service as flight number GA 142 from Soekarno–Hatta Airport, Jakarta to Sultan Iskandar Muda Airport, Banda Aceh, via Polonia Airport, Medan. There were 55 persons on board; two pilots, four flight attendants, and 49 passengers. The pilot in command (PIC) was the handling pilot, and the copilot was the support/monitoring pilot for the flight.

The aircraft took off from Jakarta runway 07L at 0129 UTC[1]. During the takeoff, the number-two wheel[2] separated from its axle and fell from the aircraft onto the runway. The flight proceeded outbound from Jakarta, climbing to flight level (FL) 320, and tracking in accordance with radar vectors from the Jakarta Approach Controller. At 0131 the controller instructed the crew to stop the climb at 10,000, and informed the crew that one of the aircraft's main wheels had fallen from the aircraft onto the runway during the takeoff. The crew subsequently levelled off at 10,000 feet.

The PIC decided to return to base (Jakarta), and proceeded to a holding point at 6,000 feet, and held for about 90 minutes to burn fuel, before landing at Soekarno-Hatta Airport, Jakarta.

Shortly after finding the aircraft wheel on the runway shoulder, the ATC closed runway 07L for about 6 minutes to perform runway sweeping to clean it of any foreign objects.

Before landing, the PIC elected to conduct a flight along runway 07L at 200 feet for an air traffic control (ATC) observation of the landing gear. The controller confirmed that the number-two main wheel was not on the aircraft. The PIC informed the controller that they would land the aircraft on runway 07L from the subsequent approach. The controller informed the airport rescue and fire fighting service (RFFS) and RFFS personnel and vehicles stood by during the landing.

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[1] The 24-hour clock used in this report to describe the time of day as specific events occurred, is in Coordinated Universal Time (UTC). Local time, Western Indonesian Standard Time (WIB) is UTC+ 7 hours.

[2] Main landing gear wheels are numbered one to four with wheel number one the left outboard, and wheel number four the right outboard.

The PIC taxied the aircraft off the runway and stopped it on taxiway NP1. The passengers disembarked normally via airstairs about 15 minutes after the landing. The RFFS crews were standing by the aircraft in case of fire. None of the aircraft's occupants were injured.

The aircraft was subsequently towed to a remote area on the airport apron for inspection.

Figure 1: View after landing showing the number-two axle without wheel

1.2 INJURIES TO PERSONS

Table 1: Injuries to persons

Injuries	Flight crew	Passengers	Total in Aircraft	Others
Fatal	-	-	-	-
Serious	-	-	-	-
Minor	-	-	-	Not applicable
Nil Injuries	6	49	55	Not applicable
TOTAL	6	49	55	-

1.3 DAMAGE TO AIRCRAFT

The number-two main wheel separated from the axle. The axle was damaged and required replacement. However, the aircraft was not damaged.

Figure 2: The number-two main wheel separated from its axle

Figure 3: Damaged inner and outer wheel bearing race on number-two axle

Figure 4: Number-two main wheel hub assembly after removal of the tire.

1.4 OTHER DAMAGE

The detached number-two main wheel rolled across the runway and hit one of the runway lights. The light was destroyed by the impact forces.

1.5 PERSONNEL INFORMATION

The pilots held valid licenses and ratings for the operation of the aircraft. This section covering flight crew is not relevant to this serious incident.

Aircraft maintenance engineers, licensed on the Boeing 737 airframe, installed the number-two main wheel on the aircraft on 23 October 2009. The engineers had recent experience in the servicing of Boeing 737 landing gear; specifically brake and wheel changes.

1.6 AIRCRAFT INFORMATION

1.6.1 General

Registration Mark	:	PK-GGQ
Manufacturer	:	Boeing Company
Country of Manufacturer	:	United States of America
Type/ Model	:	Boeing 737-300
Serial Number	:	28739
Date of manufacture	:	1997
Certificate of Airworthiness		
Valid to	:	13 November 2009
Time Since New	:	28,187 hours 49 minutes
Cycles Since New	:	21,604 cycles
Last C Check 7 July 2009	:	27,623 hours / 21,162 cycles

At the time of the serious incident, the aircraft was certified as being airworthy.

1.6.2 Number-two main wheel

The number-two main wheel hub was a factory new component from the manufacturer, and it was assembled at the Garuda Maintenance Facility on 12 June 2009. The wheel assembly was installed on the aircraft on 28 September 2009.

During the daily inspection on 22 October 2009, the brake unit of main wheel number-two required replacement. In order to replace the brake unit, the wheel was removed. The installation of the new brake unit was carried out at 02:00 am local time on 23 October 2009.

From 28 September 2009 to 22 October 2009 there were 154 flight cycles. From 23 October 2009 to 30 October 2009 at the time of serious incident, there were 48 flight cycles.

1.7 METEOROLOGICAL INFORMATION

Not relevant to this serious incident.

1.8 AIDS TO NAVIGATION

Not relevant to this serious incident.

1.9 COMMUNICATIONS

There was normal communication between the ATC and the flight crew.

1.10 AERODROME INFORMATION

Not relevant to this serious incident.

1.11 FLIGHT RECORDERS

The aircraft was equipped with a Solid State Digital Flight Data Recorder (SSFDR) P/N 980-4700-001 S/N 3259, and a Solid State Cockpit Voice Recorder (SSCVR) P/N 980-6022-001 S/N 61733 with 2-hour recording time.

The flight recorders were quarantined by the National Transportation Safety Committee investigators. The Cockpit Voice Recorder data was downloaded for the investigation, but engineering evidence showed that the FDR and CVR data were not needed for the investigation and so the recorders were returned to the operator.

1.12 WRECKAGE AND IMPACT INFORMATION

Not relevant to this serious incident.

1.13 MEDICAL AND PATHOLOGICAL INFORMATION

No medical or pathological investigations were conducted as a result of this serious incident, nor were they required.

1.14 FIRE

There was no pre- or post-incident fire.

1.15 SURVIVAL ASPECTS

None of the occupants were injured, and they vacated the aircraft unaided via airstairs.

1.16 TESTS AND RESEARCH

Not relevant to this serious incident.

1.17 ORGANIZATIONAL AND MANAGEMENT INFORMATION

Operator : PT. Garuda Indonesia

Address : Management Building
Garuda City Center
Soekarno-Hatta Airport
Jakarta 19130

The organization that performed the aircraft maintenance, PT. GMF AeroAsia, is a Directorate General of Civil Aviation (DGCA) approved Aircraft Maintenance Organization.

1.18 ADDITIONAL INFORMATION

1.18.1 Laboratory examination of failed component

The number-two main wheel separated from the axle of the left main landing gear.

A laboratory examination was performed on the number- two main-wheel assembly. The examination was performed by NTSC investigators at the Laboratory of Metallurgical and Material Engineering of the Institute of Technology, Bandung (ITB). The axle nut was still in its original position with its locking mechanism still in place. The failed bearings were dismantled from the axle. The outer raceways which, were still attached and in place in the wheel hub, were removed by pressing them out of the wheel hub. No bearing rollers were found in the axle and wheel hub assembly. Evidence on the inner raceway of the inboard wheel bearing indicated an under torque condition. See Part 6, Appendix A.

The torque wrench used to torque the number-two main wheel axle nut on 23 October 2009, was last calibrated on 11 June 2009. It was due to be recalibrated on 18 December 2009. Following the serious incident, the torque wrench calibration was checked in accordance with ISO 6789:2003. Measured values were found to be within tolerance.

The maintenance engineers reported that the brake change work was carried out on the apron, outside the hangar, in conditions of darkness. The engineers used a flash light to illuminate their work environment.

1.18.2 The Boeing Company information

On 25 September 2009, the Boeing Company issued an amendment to the 737-300/400/500 Aircraft Maintenance Manual (AMM) with respect to main wheel installation axle nut tightening. The AMM chapter 32-45-11, paragraph (9) (b) states:

> While you turn the wheel, tighten the axle nut to 300 pound-feet lube torque.

Paragraph (9) (c) was changed from

> Loosen the nut to zero torque

to state

> Loosen the nut to near zero torque.

On 24 November 2009, The Boeing Company wrote to PT. Garuda Indonesia via PT. GMF Aero Asia[3] on the subject "Recommendation on reducing wheel torque after short service". It stated that "Boeing advises GIA that as long as the wheel is assembled correctly and the AMM is followed correctly during installation, the loss of preload torque is not a cause for concern. Given the above comments Boeing do not believe that it is necessary to check axle nut torque values at a specific interval, or believe that it is necessary to retorque axle nuts or replace wheel bearings during service."

The email referred PT. GMF AeroAsia to a number of Boeing Service Letters, including 737-SL-32-149 dated 10 December 2007, titled POSSIBLE CAUSES OF LANDING GEAR WHEEL LOSSES AND WHEEL BEARING FAILURES. The Service Letter made a number of suggestions for "OPERATOR ACTION" aimed at preventing wheel loss including: Ensure that the correct axle nut tightening procedures are used per the applicable AMM procedure; Ensure that wheel spacers (if applicable), axle nut, axle nut washer, and axle nut retention devices are correctly installed per the applicable AMM; and a number of other suggestions related to wheel bearing inspection, freedom from contaminants, grease packing.

[3] GMF is the Garuda Maintenance Facility, PT. GMF AeroAsia.

1.19 USEFUL OR EFFECTIVE INVESTIGATION TECHNIQUES

The investigation was conducted in accordance with NTSC approved policies and procedures, and in accordance with the standards and recommended practices of Annex 13 to the Chicago Convention.

2 ANALYSIS

The investigation determined that the detachment of the number-two main wheel from its axle was due to the catastrophic failure of the wheel bearings. It is likely that the bearing failures resulted from an under-torque condition during the re-installation of the number-two main wheel, following the replacement of the brake unit. The investigation determined that it was likely that the wheel was not correctly positioned on the axle when the wheel nut was being tightened. The manufacturer's specified torque value was reported to have been applied. However, if the wheel was not correctly positioned on the axle, once the aircraft was lowered back onto the ground and with the aircraft weight on wheels, the wheel may have moved on the axle. The torque value of the wheel nut may then have been inaccurate, and therefore less than manufacturers specifications. The torque value applied at fitment may therefore have been false.

This situation has been known to arise due to a wheel not being rotated continuously during axle nut tightening. Bearing failures resulting from an under torque condition, progress rapidly.

In this case, it is likely that the under-torque condition, and resultant catastrophic bearing failure, ultimately caused the wheel hub to separate from its axle.

Maintenance practices and personnel working conditions significantly influence the correctness of applied procedures. Tasks performed during the hours of darkness are not necessarily unsafe. If the work environment is appropriately illuminated and work procedures are followed, maintenance can be performed safely and successfully. The investigation determined that the work environment was not conducive to ensuring that the work could be performed safely and in accordance with approved procedures.

3 CONCLUSIONS

3.1 FINDINGS

- Both pilots held valid licenses and ratings for the operation of the aircraft.

- The aircraft was certified as being airworthy at the time of the serious incident.

- It is likely that the number-two main-wheel bearings failed due to the wheel axle nut not being at the correct torque, as a result of the wheel not being correctly positioned on the axle when the wheel nut was being tightened.

- The incorrect fitment of the wheel on its axle caused the catastrophic bearing failure, and the wheel hub to separate from its axle.

- The wheel was installed by qualified personnel at the operator's approved aircraft maintenance organization.

- The torque wrench used to torque the axle nut was within calibration tolerance.

- The wheel installation was conducted on the airport apron during the hours of darkness, and flash lights were used to illuminate the work.

- The work environment was not conducive to ensuring that the work could be performed safely and in accordance with approved procedures.

3.2 CAUSES

- The determined that it was likely that the number-two main wheel bearings failed due to the wheel axle nut not being at the correct torque. The under-torque condition, and resultant catastrophic bearing failure, would have then caused the wheel hub to separate from its axle.

- The recent main-wheel installation had been conducted on the airport apron during the hours of darkness, and flash lights were used to illuminate the work. The work environment was not conducive to ensuring that the work could be performed safely and in accordance with approved procedures.

4 SAFETY ACTION AND RECOMMENDATIONS

4.1 SAFETY ACTION

4.1.1 PT. GMF AeroAsia

On 6 November 2009, PT. Garuda Indonesia informed the National Transportation Safety Committee (NTSC) that the following safety actions has been taken or commenced by PT. GMF AeroAsia following the serious incident. Much of the safety action followed from discussions between NTSC investigators, PT. Garuda Indonesia, and PT. GMF AeroAsia as a result of the *Failure Analysis Report* from the Laboratory of Metallurgical and Material Engineering of the Institute of Technology, Bandung. See Part 6, Appendix A.

Quality Assurance Reminder Number QAR-2009-09 was published to all maintenance personnel emphasizing the importance of maintaining the work quality and safety. It referred engineers to Aircraft Maintenance Manual (AMM) Chapter ATA 32-45-11.

The aim of the document was to prevent damage, and to improve the work quality and safety during replacement of wheel and brake system.

The document emphasized that all work should be performed in accordance with the current maintenance manual, and a copy of the manual should be available to all personnel performing wheel replacement work.

In addition, several warnings were also issued:

- Avoid dropping bearings during work, in order to prevent bearing contaminated from sand, dust and also to prevent bearing deformation;
- Don’t pour excessive grease between the bearing and the axle to prevent overheating;
- Make sure only calibrated tools, in particular torque wrench, are used;
- Make sure sufficient lighting is available (at least 150 watts) if the work has to be performed on a dark night;
- Rotate the wheel clockwise while tightening the nut until it reaches the desired torque;
- Avoid over torque or under torque during tightening the nut.

PT. GMF AeroAsia also scheduled a wheel removal/installation retraining program for all maintenance engineers, to be completed by 19 February 2010.

On 6 November 2009 PT. GMF AeroAsia issued Engineer Order B3/P32-45-0368, titled Main Gear Wheel Axle Nut Torque Check and Inner & outer Bearing Replacement, which was required to be performed no later than 13 November 2009.

On 10 November 2009, PT. GMF AeroAsia issued Engineer Order B3/P32-45-0368 R1, titled Main Gear Wheel Axle Nut Torque Check and Inner & outer Bearing Replacement, in order 'to add some aircraft effectivity'. Compliance with the Engineering Order instructions was required on all aircraft no later than 30 November 2009.

On 10 December 2009, PT. GMF AeroAsia wrote to The Boeing Company suggesting that the Aircraft Maintenance Manual (AMM) should be 'revised to provide a definitive value for the mechanic to work to", with respect to AMM instructions for wheel axle nut torque values. The Boeing Company responded on 10 December 2009 stating, "we have no technical objection if GIA[4] wishes to use a value such as the 747 value[5]. GIA can submit a COC[6] per standard procedures".

On 11 January 2010, PT. GMF AeroAsia wrote to the NTSC and advised the following[7]:

> On 23 December 2009 PT. GMF AeroAsia wrote to the Boeing Company submitting a COC to the AMM Boeing 737-300/400/500 Page 408, to amend the [value of running torque between the first and second torquing] "near zero" torque reduction requirement before final torque during wheel fitment to require reduction "to 10 – 100 pound feet".
>
> The Boeing Company representative in Jakarta informed PT. GMF AeroAsia that the AMM will be amended at the next scheduled revision around the middle of 2010.

[4] GIA actually refers to PT.GMF AeroAsia.

[5] 747 value referred to Boeing 747 AMM, which states a specific torque value instead of the term near zero in the Boeing 737 AMM, see this report paragraph 1.18.2.

[6] COC refers to Customer Originated Change.

[7] Details of the letter from PT. GMF AeroAsia to the NTSC have been summarized to cover only the COC points.

On 31 December 2009, PT. GMF AeroAsia issued Engineering Information (EI) No. B3/32-45-0327/EI for Boeing 737-300/-400/-500 aircraft titled B737 CLASSIC MAINWHEEL AXLE NUT TORQUE INFORMATION. It listed the Technical Data Affected by the EI as AMM 32-45-11. The document provided the following information:

> REASON
>
> Following incident of departed wheel of PK-GGQ on 30 October 09, Boeing message has been issued to prevent the further incident per Ref/B&C/. Finally, No technical objection has been issued to quantify the value of running torque between 1st torquing and 2nd torquing per Ref/A/. The aim of this EI is to provide information of torque procedure for the main wheel axle nut.
>
> DESCRIPTION
>
> On the causal factor of the departed wheel is that the wheel is improper installed on a Main Landing Gear. The current AMM 32-45-11 Page 408 (25-Sep-2009) informs qualitative value "Near Zero Torque", therefore this would be misleading to the mechanic who is performing the axle nut torquing. In order to strengthen the proper installation due to qualitative procedure, Boeing was requested to revise the procedure Sub task 32-45-11-644-046 (9) © under COC (Customer Originated Changes) on 23-Dec-2009. This Engineering Information covers the interim procedure of main wheel installation.
>
> SUGGESTED ACTION
>
> As interim procedure, Engineering recommends line maintenance and base maintenance to perform new procedure when installing a main wheel. After tightening the axle nut to 300 lb. ft, the nut is loosened to 10-100 lb.ft before tightening final torque to 15o lb.ft. This new procedure is revised from qualitative measurement to quantitative measurement.

On 4 February 2010, the Boeing Company's Manager of Customer-Originated Change Group wrote to PT. GMF AeroAsia informing them that:

> The subject Customer Originated Change has been reviewed for incorporation into your B737-345 maintenance Manual, D6-37601.

The Boeing advice also indicated that subject to specific commercial terms and conditions being met:

> This request may be incorporated in the September 25, 2010 revision...

4.1.2 Directorate General of Civil Aviation

On 12 January 2010, the Directorate General of Civil Aviation informed the National Transport Safety Committee that it had taken the following safety actions.

On 4 November 2009, the DGCA wrote to PT. Garuda Indonesia with respect to Boeing 737 landing gear wheels:

> Preventive Action letter number DKPPU/4257A/STD/2009 on 4 November 2009 to VP of Corporate Quality, Safety & Aviation Security PT Garuda Indonesia to:
>
> a. re-do torque on Main and Nose Wheel of all B737 aircraft operated by PT Garuda Indonesia at the earliest daily check (first opportunity).
> b. pass the accident information to Boeing (Aircraft Manufacture) and Honeywell International (Wheel Vendor) to get further evaluation.

On 10 November 2009, DGAC held a meeting with PT. Garuda Indonesia, which resulted in additional recommendations for preventive actions to be taken by PT. Garuda Indonesia as follow:

> a. PT Garuda Indonesia should conduct Refresher Training to all its Line Maintenance Division mechanics and engineers on how to install/fit *wheel* and *handling bearing* in accordance to current procedures.
> b. PT Garuda Indonesia is asked to instruct the Wheel Shop of GMF AeroAsia to give refresher training to all its employees about the inspection and standarisation, maintenance, handling, shipping and bearing storage in accordance with current procedure.
> c. PT. Garuda Indonesia is recommended to make a checklist/jobcard about how to to install/fit a wheel to an aircraft.

4.2 SAFETY RECOMMENDATIONS

As a result of this serious incident investigation, the National Transportation Safety Committee made the following recommendation.

4.2.1 Recommendation to PT. Garuda Indonesia

The National Transportation Safety Committee recommends that PT. Garuda Indonesia should ensure that its maintenance providers' procedures and practices include appropriate guidance documentation, training, supervision, and appropriate maintenance environment.

4.2.2 Recommendation to PT. GMF AeroAsia

The National Transportation Safety Committee recommends that PT. GMF AeroAsia should review its maintenance procedures and practices to ensure that appropriate guidance documentation, training, and supervision is provided, to ensure that correct practices are followed, and an appropriate maintenance environment is available at all times.

4.2.3 Recommendation to Directorate General of Civil Aviation

The National Transportation Safety Committee recommends that the Directorate General of Civil Aviation should review the PT. Garuda Indonesia maintenance procedures and practices of documentation, and supervision practices during airworthiness surveillance audit inspections.

- Specifically, the DGCA should ensure that appropriate guidance documentation, training, and supervision are provided, to satisfy itself that correct practices are followed, and an appropriate maintenance environment is available at all times.

5 APPENDIX

Appendix A: Failure Analysis Report from Laboratory of Metallurgical and Material Engineering of the Institute of Technology, Bandung (ITB)

Laboratory of Metallurgy and Materials Engineering

Faculty of Mechanical and Aeronautical Engineering - ITB

FAILURE ANALYSIS REPORT ON

THE DETACHMENT OF NUMBER 2 WHEEL FROM THE AXLE OF GARUDA INDONESIA BOEING 737-300 AIRCRAFT PK-GGQ AT SOEKARNO – HATTA AIRPORT ON 30 OCTOBER 2009

1. Failed Components

The number-2 wheel of Garuda Boeing 737–300 aircraft PK-GGQ detached from the axle. The detachment was due to the bearing failure. The NTSC sent the failed wheel hub, bearings and the related parts to the Laboratory of Metallurgy and Materials Engineering for a failure analysis to determine the cause of failure.

2. Back-ground Information

The wheel detachment occurred during a take-off roll on the runway of Soekarno-Hatta Airport, Jakarta on 30 October 2009.

A brief history of the wheel assembly is as follows:

A batch of five sets of wheel hubs was purchased from Honeywell, including the outer race of the bearings in September 2009.

One of the wheel hub assembly was installed on the PK-GGQ aircraft on 28 September 2009

On the evening off 22 October 2009 it was found that the brake pad indicator showed that the brake assembly should be replaced by a new one. From 28 September 2009 to 23 October 2009 there were 154 flight cycles (takeoff and landing cycles)

On 23 October 2009 a night shift crew A removed the wheel assembly, replaced the brake assembly and reinstalled the wheel assembly. The job was done at about 2 o’clock AM.

On 30 October 2009, during the second takeoff of the day the wheel was detached from its axle after airborne. The detached wheel then rolled on the runway and hit a runway light. There were 48 flight cycles from 23 October 2009 until the time of the serious incident on 30 October 2009.

The axle nut was still on its original position with its locking mechanism. The failed bearings were dismantled from the axle on 4 November 2009 (Figure 1). The outer raceways which were still attached on its place in the wheel-hub were then removed by pressing them out of the wheel hub. There was no bearing roller found in the axle and wheel hub assembly.

Figure 1: Bearing failures on the axle.

Note the axle nut and the severely deformed spacer.

3. Observations

Visual observation on the inner race of the inboard bearing (Figure2) showed indentation marks of the rollers at about equal distance on the shiny surface of the raceway (Figure 3).

Figure 2: Shiny surface of the inner raceway of the inboard bearing

Figure 3: Roller impressions on the shiny surface of the inner raceway were indications of true Brinelling as a result of under torque.

Each of indentation markings showed two lines; one line was parallel to the axis of the axle, and another line was at angle to the axis.

The inner race of the outboard bearing showed a dull appearance with several roller indentations (Figure 4).

Figure 4: Dull surface on the inner raceway of the outboard bearing.

Note the roller impressions indicating false Brinelling due to vibration.

4. Analysis

4.1. The marking lines on the shiny surface of the inner race are indentations of the rollers. It is a characteristic of true Brinelling which is associated with improper mounting of the bearing[8], in this case due to an under-torque situation. This situation might lead to a misaligned of the rollers relative to the raceway causing the contact surface to be smaller. The roller markings were also due to hammering during static loading. In case of such an under torque, excessive loads were exerted between the rollers and the raceway. It caused an abnormal operation of the bearing, and led to destruction to the bearings.

4.2. The dull appearance on the inner race of the outboard bearing was a result of vibrations and interactions with metallic debris. The impressions of the rollers on the inner raceway were not so prominent. This characteristic was known as false Brinelling.

4.3. After a severe damage on the bearing including detachment of rollers from the wheel assembly, the wheel came-out from its axle.

5. Conclusion

It can be concluded that the cause of the bearing failures was due to improper mounting of the bearing and wheel assembly, more specifically due to an under torque.

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[8] The ASM Committee on Failures of Sliding and Rolling Element Bearings, ASM Handbook volume 11, Failure Analysis and Its Prevention, 1973.

6. Recommendation

To prevent an improper wheel mounting, more specifically an under torque situation, a continuous rotation of the wheel shall be performed during tightening, loosening (until zero torque) and re-tightening of the axle nut to the prescribed torque value.

(Original signed)

Bandung, 5 November 2009

Dr. ir. Mardjono Siswosuwarno

(Professor in Mechanical Metallurgy (Professor in Mechanical Metallurgy)