# FINAL REPORT Nr. 3/2009
# OF THE SERIOUS INCIDENT

## TO BOEING 737-500 AIRCRAFT, REGISTRATION YL-BBE OF S/C "AIR BALTIC CORPORATION" FLIGHT BT-662 ON DECEMBER 31, 2008 AT DUBLIN

**The Aircraft Accident and Incident Investigation Bureau of the Republic of Latvia is a governmental, independent of all aviation authorities, organization established by law to investigate and determine the cause or probable cause of accidents and serious incidents that occurred in the civil aviation, as well if necessary for enhancing flight safety incidents.**

**The sole purpose of such investigation is in accordance with Annex 13 of the Convention of Chicago, as well as the Directive 94/56/EC of 21 November 1994, establishing the fundamental principles governing the investigation of civil aviation accidents and incidents of the Council of the European Union, to prevent accidents and incidents and, if the Bureau finds it appropriate, to make safety recommendations. The purpose of an investigation conducted under the responsibility of the Aircraft Accident and Incident Investigation Bureau Republic of Latvia is not to apportion blame or liability.**

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**Director of Transport Accident and Incident Investigation Bureau** **Ivars Alfreds Gaveika**

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## CONTENTS

**Abbreviations**

AAIB - Air Accident Investigation Branch
ASE - Aviation Safety Engineers
ADREP - Accident/Incident Reporting System
ALPA - Air Line Pilots Association
AMM - Aircraft Maintenance Manual
CAA - Civil Aviation Authority
COS - Continued Operational Safety
CMM - Component Maintenance Manual
FTD's - Fleet Team Digest articles
ICAO - International Civil Aviation Organisation
MCC - Movement Control Center
NLR - National Aerospace Laboratory
NTSB - National Transportation Safety Board
TSB - Transportation Safety Board
CVR - Cockpit Voice Recorder
LH MLG - Left Hand Main Landing Gear
RH MLG - Right Hand Main Landing Gear
PIC - Pilot in Command
F/O - First Officer
ATC - Air Traffic Control
CPL - Commercial Pilot Licence
ATPL - Airline Transport Pilot Licence
UTC - Universal Time Coordinated
TO - Take-Off

## Notification

The Transport Accident and Incident Investigation Bureau (TAIIB) was informed of this event on December 31, 2008 from chief of the Department of Latvian ATC at 15.10 UTC before the aircraft Boeing 737-500 YL-BBE was entered to Riga (EVRA) FIR and by fax message form ARCC about "Air Baltic Corporation" airlines Boeing 737-500 aircraft YL-BBE Serious Aviation Incident at 17:57 UTC.

## Synopsis

***Unless stated otherwise all times in this Report are UTC time***

The "Air Baltic" airlines aircraft was operating a scheduled passenger service flight BT-662 from Dublin to Riga. The incident to the Boeing 737-500 YL-BBE aircraft occurred on the second flight (following a 3 day maintenance check) during take off from Dublin Airport (EIDW) Runway 10, to Riga (EVRA) International Airport on December 31, 2008 having performed flight No BT-662.

## General information of the serious incident

| | | |
|---|---|---|
| Operator | - | S/C „Air Baltic Corporation" |
| Aircraft Type | - | Boeing 737-500 |

| | | |
|---|---|---|
| Nationality | - | Latvian Republic |
| Registration | - | YL-BBE |
| Manufacturer | - | The Boeing Commercial Airplane Company, Seattle, Washington, USA |
| Owner | - | S/C „Air Baltic Corporation” |
| Date of manufacture | - | November 30, 1998 |
| Place of Accident | - | Dublin Airport (EIDW), Ireland |
| Date and time | - | 31 December 2008, approximately at 13:41 UTC |

## Investigation

The investigation was performed by investigators of the Transport Accidents and Incidents Investigation Bureau (TAIIB) of the Republic of Latvia. The Flight safety report No 081231 BT-662 by fax message form about “Air Baltic Corporation” airlines Boeing 737-500 aircraft YL-BBE Serious Aviation Incident was notified to the Transport Accidents and Incidents Investigation Bureau (AAIB) from the AS “Air Baltic Corporation” on January 2, 2009 at 09:32 UTC.

## 1. FACTUAL INFROMATION

### 1.1. History of the flight

On December 31, 2008 a Boeing 737-500 with registration number YL-BBE of “Air Baltic” airlines executed a scheduled passenger service flight from Dublin (EIDW) airport to Riga (EVRA). During Line up “Autobrake Disarm” light come On. Reset RTO successful and the crew continue flight. After take off passenger called Cabin crew, when “Seat Belt” sign come off and reported, that during the take off the burning right hand main outboard wheel separated from the aircraft. The Cabin crew reported this to Pilot-in-command. First officer was sent to look as well and he reported no wheel on right hand Landing gear.

The crew decided to continue the flight to Riga after they confirmed the situation by means of a visual check through the gear inspect window. QRH was checked and most probable checklist “Partial or All Gear Up” was advised. Expecting Emergency Landing, ATC was advised. In order to have a minimum fuel upon landing ATC transponder code 7700 was set. Information BYR the crew about lost right hand main landing gear was forwarded from UK ATC to other ATC along the route, but did not inform the ATC of Dublin airport, what was very important for flight safety of others departing airplanes from Runway 10 at the airport.

CC was briefed and passengers informed according “Air Baltic” emergency procedures. Emergency landing was declared and performed successfully as planned with flaps 40 degrees on left main wheel on minimum speed 107 knots extremely soft (1.08G) at Riga Airport. No remarks from passengers and good cooperation with ATC. After landing runway has been vacated and passengers disembarked by standard procedure from external stairs. Right hand landing gear outer main wheel No. 4 was missing. It was found in Dublin airport near Runway 10 and Taxiway E2.

# RH Outer wheel in Dublin

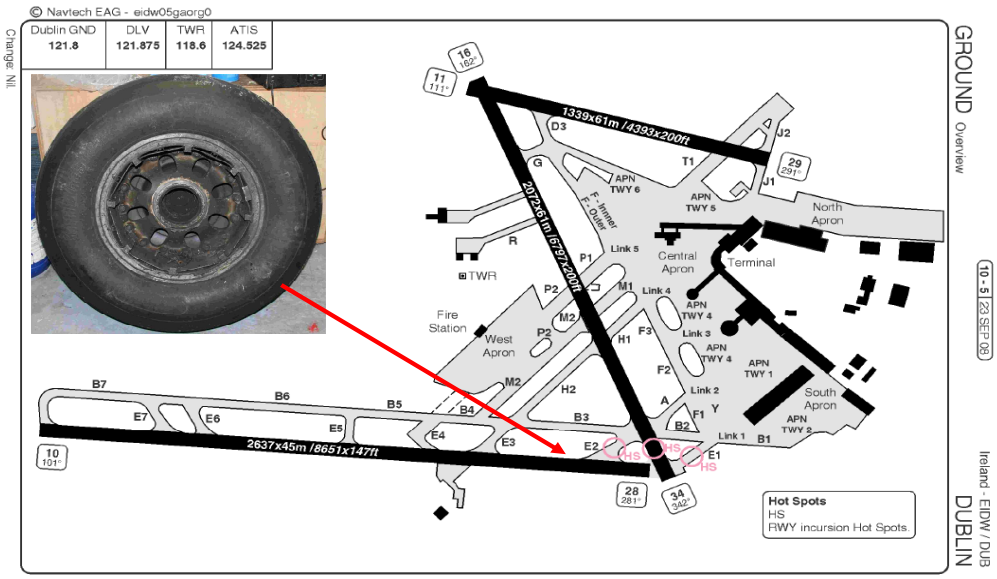



**Figure 1. Dublin –EIDE/DUB, Ireland**


**Figure 2. Flight route**

## 1.2. Injuries to persons

None

### 1.3. Damage to aircraft

As result of technical inspections the following damaged parts of aircraft were found:

- Parts of Nr. 4 wheel inner and outer bearing was found on the axle;
- The Nr. 4 brake unit was found damaged;
- The Nr. 4 wheel antiskid transducer was found damaged;
- The RH MLG outboard axle sleeve was found damaged and the sleeve had rotated;
- The Nr. 4 wheel axle nut and washer were found damaged;
- The Nr. 4 wheel axle nut retainer ring was found missing;
- The RH MLG axle was found damaged at the threads on outboard side;
- The RH MLG axle was found to have evidence of overheat damage in the bore of the axle on outboard side.

The RH MLG outboard axle sleeve pin was found damaged. It was decided that the RH MLG assembly, brake Nr. 4, antiskid transducer Nr. 4 and the wheel Nr .4 shall be changed.

### 1.4. Other damage

None

### 1.5. Personnel information

The flight crew certified and qualified for the flight in accordance with existing regulations.

| | |
|---|---|
| **PIC** | -male, age - 46; |
| Licence | - ATPL (A) LVA-JAA 075A issued 05.03.2008; |
| | - Validity - 05.03.2013; |
| | - Rating - B-737; |
| Total flying experience | - 8246 hrs; |
| Flying experience as captain (PIC) | - 2746 hrs; |
| Flying experience on aircraft type | - 721 hrs; |
| Flaying hours in incident day | - 06 hrs 40 min; |
| Flaying time 72 hrs before incident | - 07 hrs 46 min; |
| Flaying time 7 days before incident | - 30 hrs 41 min; |
| Last examination of pilot qualification | - OPC (valid till 31.10.2009.); |
| Last medical examination | - 03.04.2008 (valid till 03.04.2009.). |
| | |
| **First Officer** | - male, age - 27; |
| Licence | - I - CPL (A) 023623 issued 02.04.2008; |
| | - Validity - 09.04.2012; |
| | - Rating - B-737; |
| Total flying experience | - 1855 hrs; |
| Flying experience on aircraft type | - 525 hrs; |
| Flaying hours in incident day | - 06 hrs 40 min; |
| Flaying time 72 hrs before incident | - 10 hrs 49 min; |
| Flaying time 7 days before incident | - 10 hrs 49 min; |
| Last examination of pilot qualification | - OPC (valid till 31.10.2009.); |
| Last medical examination | - 27.03.2008 (valid till 27.03.2009.). |

## 1.6. Aircraft Information

Aircraft type - Boeing 737 - 500;
Manufacturer - Boeing Commercial Airplane Company, Seattle, Washington, USA;
Manufacturer's serial No - 29073;
Model - 737-53S;
Owner of aircraft - Pembroke B737-7006 Leasing limited;
Registration - YL-BBE;
Validity of the Certificate of Registration - Date of issue on 26 June 2008;
Year of manufacture - 30 November 1998;
Total aircraft flying hours - 25 159 hrs;
Cycles - 17 662;
Flight hrs (since last periodic inspection) - 2 078 hrs, Cycles - 1 307;
Engines manufacturer and Model - c FM56-3-c1;

Serial No.:
Left - 858973;
Right - 858968;
The left (number 1) engine had accumulated - 25 159 hours;
The right (number 2) engine had accumulated - 24 548 hours;
Validity of the Certificate of Airworthiness - Valid until - 05.05.2009;
Max take off weight - 56245;
Actual take off weight - 51396;
Balance MACTOW - 24, 9;
Balance MACLAW - 24, 5.

### 1.6.1. Main Landing Gear Wheel hub on B737-500 consists as shown below

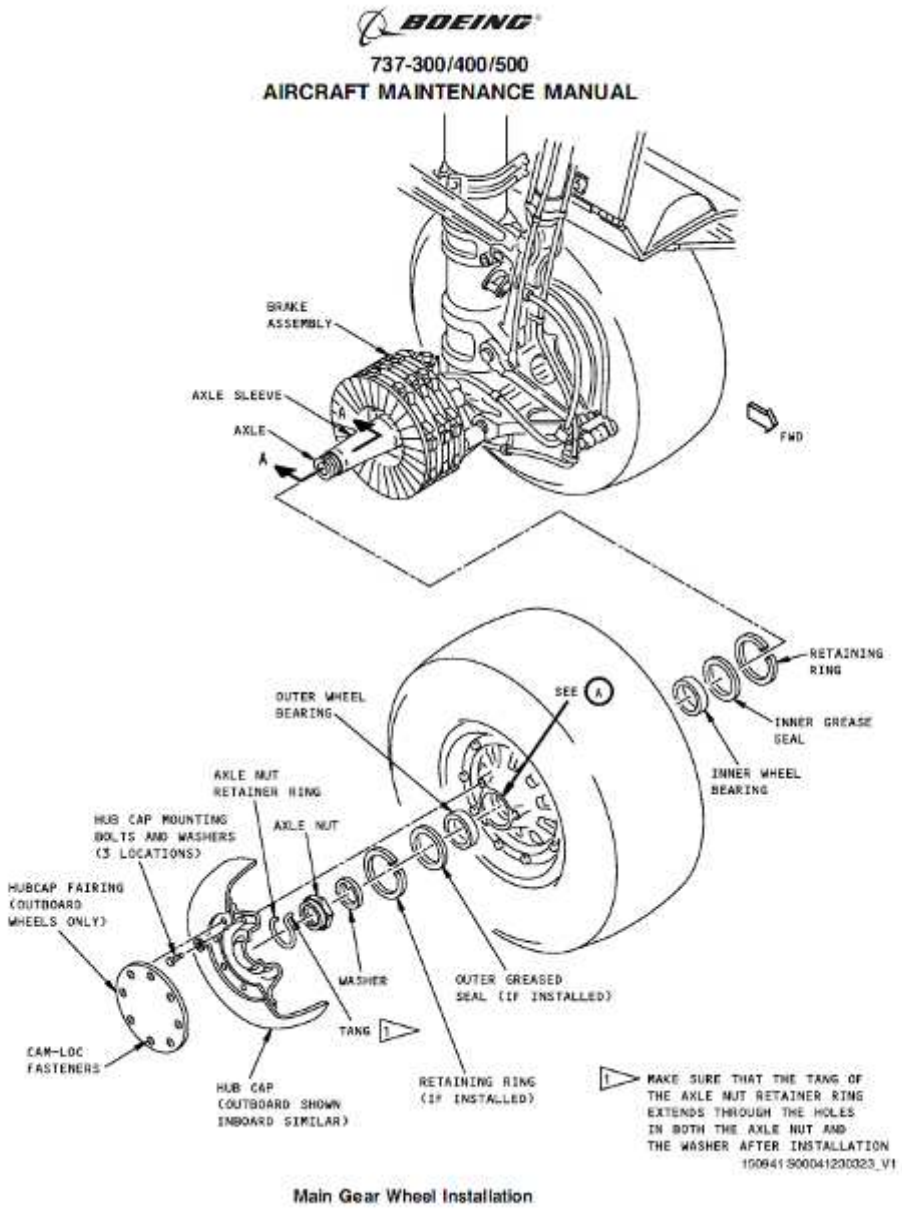



**Figure 3. Main Landing Gear Wheel hub on B737-500**

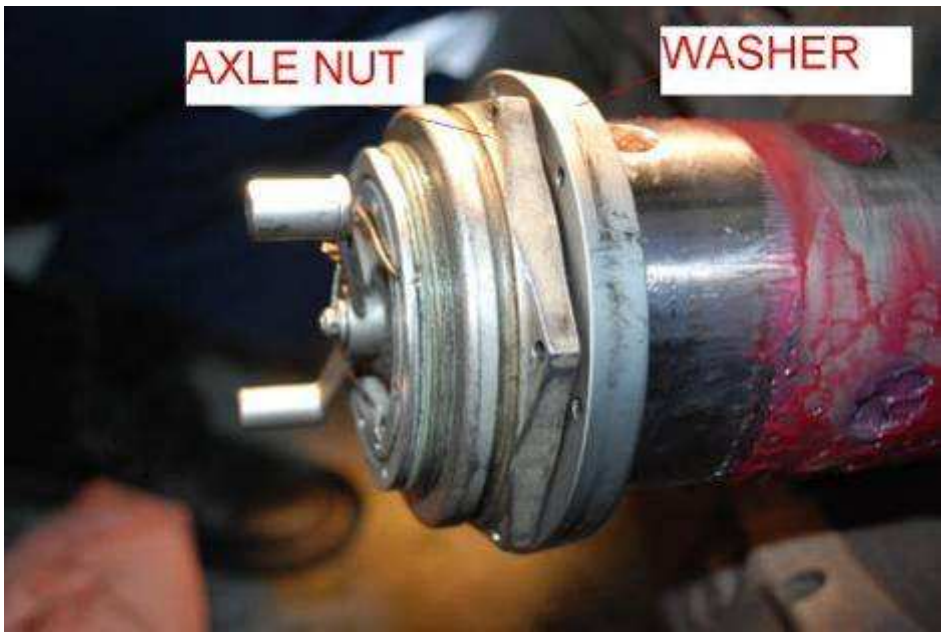



**Figure 4. Wheel disc with tire are held in position BYR WASHER and AXLE NUT**

**Figure 5. To prevent nut coming loose during operation nut is locked with AXLE NUT RETAINER RING, which locks WASHER and nut together**

**Figure 6. WASHER is locked from rotation on main axle by special teeth which is inserted in the grove on main axle**

### 1.6.2. Details on MLG wheel Nr.4

Wheel identificators: P/N 2609801-1, S/N B0133
Wheel manufacturer: Honeywell
Wheel assembly manufacture date: June 1989

Wheel utilization (all figures related to the time of the incident):

| Unit | Since Fit | Since New* | Since Overhaul | Since Repair |
|---|---|---|---|---|
| Days | 112 | 1175 | 365 | 113 |
| Hours | 919:46 | 11030:37 | 2801:51 | 919:46 |
| Landings | 584 | 5662 | 1644 | 584 |

* figures in column Since New do not represent the actual accumulated life for the wheel assembly. The counting has started with introduction of S/N B0133 in Airbaltic disposition. Actual accumulated life of S/N B0133 is unknown.

### 1.6.3. Maintenance activities

The MLG wheel Nr. 4, P/N 2609801-1, S/N B0133 was installed on aircraft YL- BBE on 10.09.2008. during Daily Check activities as a replacement for MLG wheel Nr. 4, P/N 2609801-1, S/N B0182/B0230. Reason for wheel replacement was wear-out to acceptable limit of MLG wheel Nr. 4, P/N 2609801-1, S/N B0182/B0230 tire.

This replacement was performed in RIX by Airbaltic category B1 maintenance technician. Since installation S/N B0133 has accumulated 919:46 FH / 584 FC/ 112 days.

During landing gear change at Istanbul by "MNG Technic" on 05/12/2008 MLG wheel S/N B0133 has been removed and refitted on new MLG as wheel Nr. 4. Since this installation MLG wheel S/N B0133 accumulated 174:13 FH / 133FC/26 days.

Last repair of S/N B0133 performed on 25.08.2008 by organization "Fly LAL Technics" included tire change. Installed tire; Bridgestone H40x14.5-19; 26PR; P/N APS01337; S/N 408NH220, in new condition. No other works performed during this repair.

Last overhaul of S/N B0133 performed on 18.10.2007 in organization "Fly LAL Technics" included tire change, and replacement of following elements: core C-4 (p/n 149598), packing RG-6 (p/n 2602195), nut (p/n 2604374), packing (p/n AS3582-012), cap VC-5 (p/n MS20813-1). No other works performed during this overhaul.

**Summary on maintenance activities**

| Date | Action | Organization | Unit Days | Unit Hours | Unit Landings |
|---|---|---|---|---|---|
| 25.08.2008 | Repair | Fly LAL | 1063 | 10110:51 | 5078 |
| 06.06.2008 | Repair | Fly LAL | 995 | 9411:32 | ^743 |
| 18.10.2007 | Overhaul | Fly LAL | 810 | 8228:46 | 4018 |
| 09.07.2007 | Repair | Fly LAL | 739 | 7501:01 | 3616 |
| 13.10.2006 | Repair | LAL | 658 | 6707:06 | 3251 |
| 19.07.2006 | Repair | LAL | 590 | 5849:01 | 2846 |
| 13.05.2006 | Repair | LAL | 529 | 5166:24 | 2497 |
| 14.12.2005 | Overhaul | LAL | 398 | 4005:06 | 1927 |
| 18.08.2005 | Repair | LAL | 320 | 3187:48 | 1511 |
| 13.06.2005 | Overhaul | | 259 | 2496:15 | 1179 |
| 29.01.2005 | Repair | LAL | 191 | 1781:19 | 811 |
| 09.09.2004 | Inspection | LAL | 69 | 739:19 | 335 |

| | | | | | |
|---|---|---|---|---|---|
| 09.02.2004 | Overhaul | North Star | 0* | 0:00* | 0* |

* The counting has started with introduction of S/N B0133 in AirBaltic disposition. Actual accumulated life of S/N B0133 is unknown.

**S/N B0133 known times between overhauls:**
2091 FC
748 FC
1179 FC
Average: 1339 FC
During the incident the time since last overhaul was 1644 FC
Average utilization between overhauls for all wheels operated by AirBaitic: 1876 FC

### 1.7. Meteorological information

METAR EIDW 311130Z 11009KT 10000 SCT018 FEW014 05/03 Q1027 NOSIG
RW 10 Runway conditions – Dry, BA/FC - Good

METAR EVRA 311320Z 19004KT 10000 OVC018 FEW014 -00/-02 Q1020 NOSIG
METAR EVRA 9999 OVC 013 SCT008 00/-02 Q1021 NOSIG

### 1.8. Aids to Navigation

EVRA RADIO NAVIGATION AND LANDING AIDS

| Type of aid, MAG VAR, Type of supported OP (for VOR /ILS /MLS , give declination) | ID | Frequency | Hours of operation | Position of transmitting antenna coordinates | Elevation of DME transmitting antenna | Remarks |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| DVOR /DME 5.0° E/ 2005 | RIA | 112.050 MHz (CH-57Y) | H24 | 565515.1N 0235754.7E | 100FT | |
| LLZ 18 ILS CAT I (5.1° E /2000) | IRV | 111.100 MHz | H24 | 565404.4N 0235803.0E | | |
| GP 18 | | 331.700 MHz | H24 | 565556.3N 0235814.3E | | GP 3.0° RDH 55 FT |
| DME 18 | IRV | CH - 48X | H24 | 565556.3N 0235814.3E | 0FT | IRV DME reading refers to THR 18. |

### 1.9. Communications

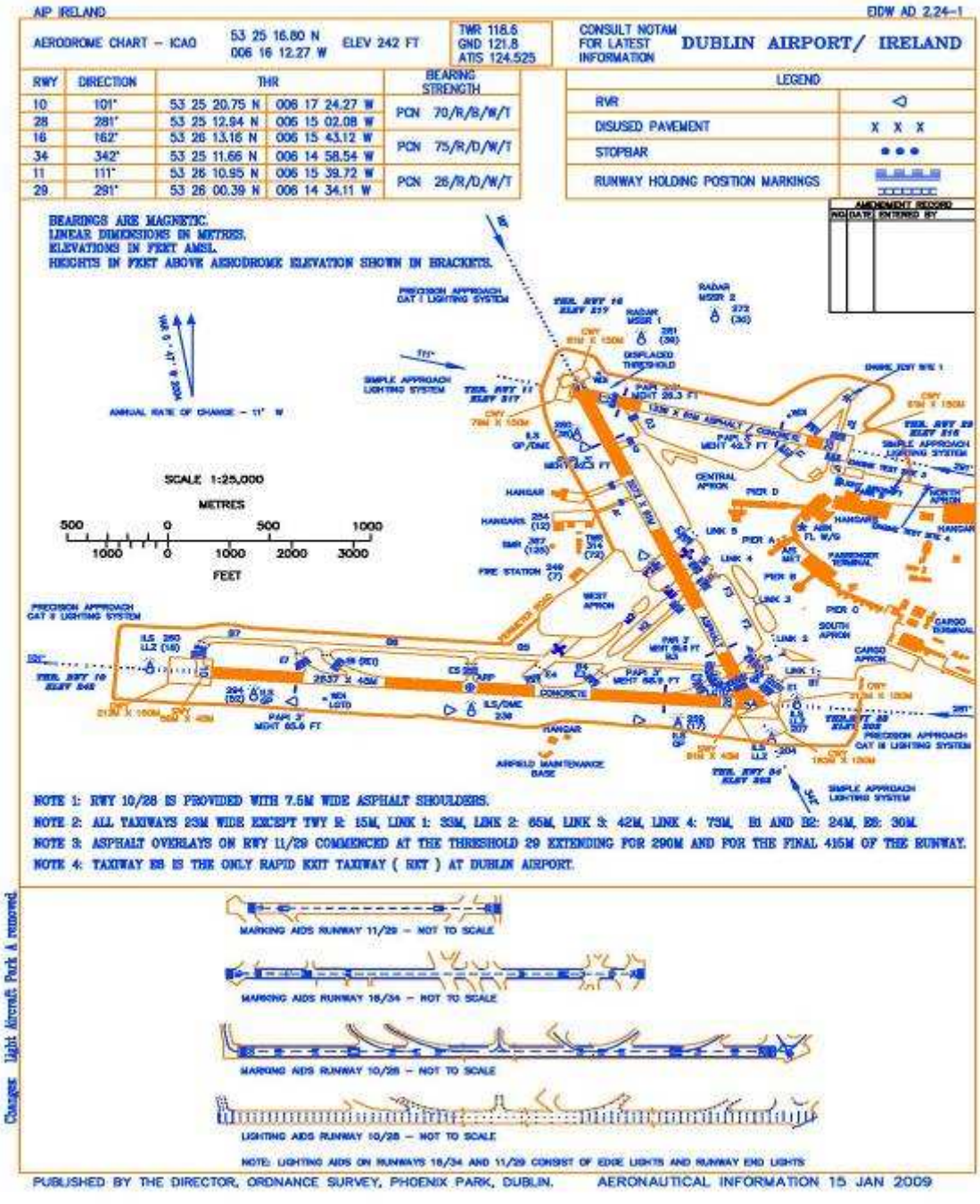
EVRA AD ATS COMMUNICATION FACILITIES

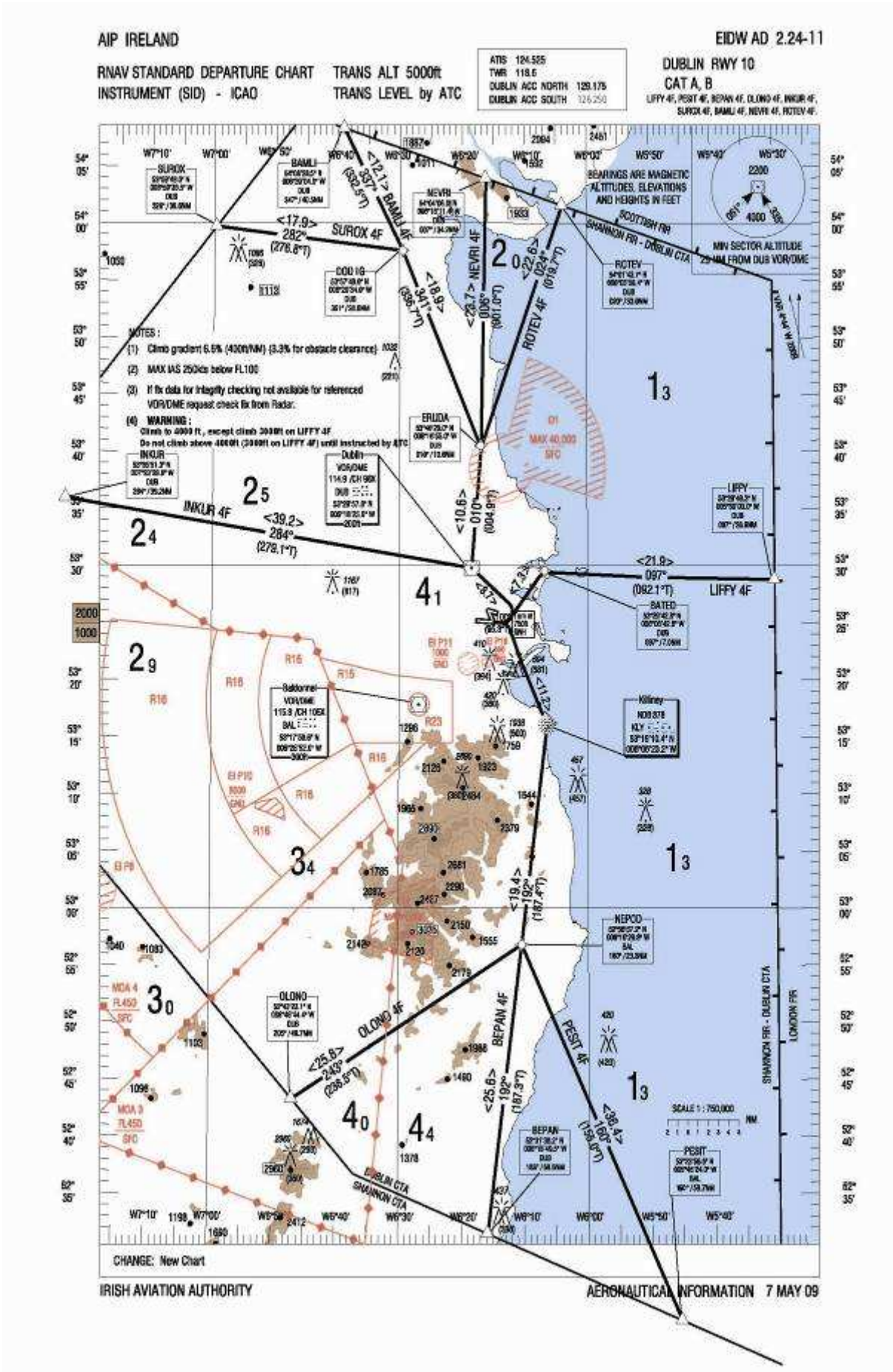
| Service designation | Call sign | Frequency | Hours of Operation | Remarks |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |
| APP | Riga Approach | 127.300 MHz | H24 | |
| TWR | Riga Tower | 118.100 MHz | H24 | |
| GMC | Riga Ground | 118.800 MHz | 0600-2200 (local time) | |
| ATIS (INFO ) | Riga Information | 121.200 MHz | H24 | ATIS service also available via data link. This service operates through ACARS network and supports aircraft equipped with ACARS which is ARINC 623 compliant. (Provider is SITA) |

The radio equipment functioned normally and had no relation with the cause of incident. Phraseology of ATC traffic controllers have conformed with „Procedures for Air Navigation Services - Air Traffic Management" 14th Edition, 2001 (ICAO Doc. 4444) Chapter 7 - Aerodrome and meteorological information Items 7.3.1.2. and 7.3.1.2.2.

### 1.10. Aerodrome information

This incident happened in good visibility during Take off from Runway 10 at daylight hours at Dublin airport.


AIP IRELAND
EIDW AD 2.24-1
AERODROME CHART – ICAO
53 25 16.80 N
006 16 12.27 W
ELEV 242 FT
TWR 118.6
GND 121.8
ATIS 124.525
CONSULT NOTAM FOR LATEST INFORMATION
DUBLIN AIRPORT/ IRELAND
RWY
DIRECTION
THR
BEARING STRENGTH
10 101° 53 25 20.75 N 006 17 24.27 W PCN 70/R/B/W/T
28 281° 53 25 12.94 N 005 15 02.08 W
16 162° 53 26 13.16 N 006 15 43.12 W PCN 75/R/D/W/T
34 342° 53 25 11.66 N 006 14 58.54 W
11 111° 53 26 10.95 N 006 15 39.72 W PCN 26/R/D/W/T
29 291° 53 26 00.39 N 006 14 34.11 W
LEGEND
RVR
DISUSED PAVEMENT
STOPBAR
RUNWAY HOLDING POSITION MARKINGS
AMENDMENT RECORD
NO DATE ENTERED BY
BEARINGS ARE MAGNETIC.
LINEAR DIMENSIONS IN METRES.
ELEVATIONS IN FEET AMSL.
HEIGHTS IN FEET ABOVE AERODROME ELEVATION SHOWN IN BRACKETS.
VAR 9° 47' W (2008)
ANNUAL RATE OF CHANGE – 11' W
SCALE 1:25,000
METRES
500 0 500 1000
1000 0 1000 2000 3000
FEET
PRECISION APPROACH CAT I LIGHTING SYSTEM
SIMPLE APPROACH LIGHTING SYSTEM
DISPLACED THRESHOLD
RADAR MSSR 1
RADAR MSSR 2
ILS GP/DME
CENTRAL APRON
NORTH APRON
SOUTH APRON
CARGO APRON
CARGO TERMINAL
PASSENGER TERMINAL
HANGAR
HANGARS
FIRE STATION
WEST APRON
AIRFIELD MAINTENANCE BASE
PRECISION APPROACH CAT II LIGHTING SYSTEM
PRECISION APPROACH CAT III LIGHTING SYSTEM
2637 X 45M
2133M X 150M
1829M X 150M
CONCRETE
ASPHALT
PAPI 3° MEHT 65.6 FT
PAPI 3° MEHT 66.9 FT
PAPI 3° MEHT 42.7 FT
PAPI 3° MEHT 28.3 FT
NOTE 1: RWY 10/28 IS PROVIDED WITH 7.5M WIDE ASPHALT SHOULDERS.
NOTE 2: ALL TAXIWAYS 23M WIDE EXCEPT TWY R: 15M, LINK 1: 33M, LINK 2: 65M, LINK 3: 42M, LINK 4: 73M, B1 AND B2: 24M, B8: 30M.
NOTE 3: ASPHALT OVERLAYS ON RWY 11/29 COMMENCED AT THE THRESHOLD 29 EXTENDING FOR 290M AND FOR THE FINAL 415M OF THE RUNWAY.
NOTE 4: TAXIWAY B8 IS THE ONLY RAPID EXIT TAXIWAY ( RET ) AT DUBLIN AIRPORT.
Changes: Light Aircraft Park A removed
MARKING AIDS RUNWAY 11/29 – NOT TO SCALE
MARKING AIDS RUNWAY 16/34 – NOT TO SCALE
MARKING AIDS RUNWAY 10/28 – NOT TO SCALE
LIGHTING AIDS RUNWAY 10/28 – NOT TO SCALE
NOTE: LIGHTING AIDS ON RUNWAYS 16/34 AND 11/29 CONSIST OF EDGE LIGHTS AND RUNWAY END LIGHTS
PUBLISHED BY THE DIRECTOR, ORDNANCE SURVEY, PHOENIX PARK, DUBLIN.
AERONAUTICAL INFORMATION 15 JAN 2009


AIP IRELAND
EIDW AD 2.24-11
RNAV STANDARD DEPARTURE CHART
INSTRUMENT (SID) - ICAO
TRANS ALT 5000ft
TRANS LEVEL by ATC
ATIS 124.525
TWR 118.6
DUBLIN ACC NORTH 129.175
DUBLIN ACC SOUTH 126.250
DUBLIN RWY 10
CAT A, B
LIFFY 4F, PESIT 4F, BEPAN 4F, OLOND 4F, INKUR 4F, SUROX 4F, BAMLI 4F, NEVRI 4F, ROTEV 4F.
BEARINGS ARE MAGNETIC
ALTITUDES, ELEVATIONS
AND HEIGHTS IN FEET
MIN SECTOR ALTITUDE
25 NM FROM DUB VOR/DME
SCOTTISH FIR
SHANNON FIR - DUBLIN CTA
SUROX 4F
BAMLI 4F
NEVRI 4F
ROTEV 4F
INKUR 4F
LIFFY 4F
OLOND 4F
BEPAN 4F
PESIT 4F
NOTES :
(1) Climb gradient 6.5% (400ft/NM) (3.3% for obstacle clearance).
(2) MAX IAS 250kts below FL100
(3) If fix data for Integrity checking not available for referenced VOR/DME request check fix from Radar.
(4) WARNING :
Climb to 4000 ft, except climb 3000ft on LIFFY 4F
Do not climb above 4000ft (3000ft on LIFFY 4F) until instructed by ATC
Dublin VOR/DME 114.9 /CH 90X
Baldonnel VOR/DME 115.9 /CH 105X
Killiney NDB 378
SCALE 1 : 750,000
CHANGE: New Chart
IRISH AVIATION AUTHORITY
AERONAUTICAL INFORMATION 7 MAY 09

### 1.11. Flight recorders

The flight data recorder (FDR) data show that the aircraft touched down at Riga airport on Runway 18 at 13:56:04 at a recorded indicated airspeed 114 knots and recorded groundspeed 109,5 knots. The aircraft touched down with a recorded normal vertical G force of 1,13g with the flaps 40 degrees.

### 1.12. Wreckage and impact information

Not damage

### 1.13. Medical and pathological information

Not relevant to this incident

### 1.14. Fire

The wheel assembly showed signs of overheating and fire. Damage due to fire was found at the hub and bearing areas. The outboard sidewall surface of the tire was burned over an area of approximately two inches around the circumference.

### 1.15. Survival aspects

Not necessity to survey

### 1.16. Tests and research

#### 1.16.1. Wheel identity

The identification information on the wheel assembly states the following:
Wheel model: Bendix H40X14.5-19
Wheel part number: 2609933
Wheel serial number: B 0133
Wheel assy number: 2609801-1 CHG A
This wheel assembly is consistent with Boeing 737 installations.

#### 1.16.2. General state

**Wheel assembly**

The wheel assembly showed signs of overheating and fire. There was no mechanical damage to the spokes. All wheel bolts and nuts were found installed. The thermal plugs installed were not activated. Damage due to fire was found at the hub and bearing areas. The outboard sidewall surface of the tire was burned over an area of approximately two inches around the circumference. The inboard sidewall of the tire contained three small cuts,

probably caused BYR impact after separation of the wheel assembly. The tire tread was in good condition except for one skid mark of approximately 3.5 x 6 inch.

**Figure 7. Wheel assembly outboard side overview**

**Figure 8. Tire sidewall surface, evidence of fire**

**Figure 9. Tire sidewall surface evidence of fire, detail**

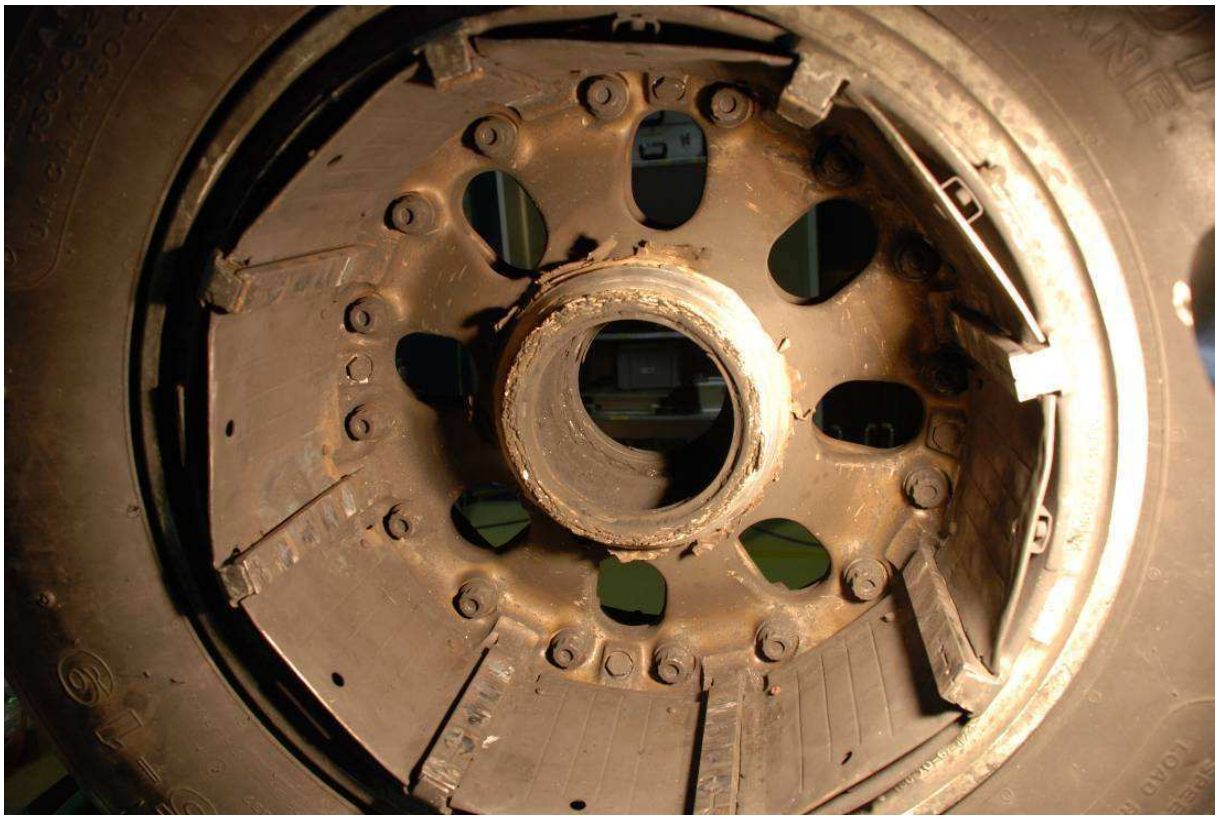


**Figure 10. Wheel assembly inboard side overview**

**Figure 11. Thermal fuse screw**

**Figure 12. Cuts in tire sidewall**

**Outboard wheel half**

The outer wheel half showed heat damage to the bearing cup. The surface of the bearing cup was partially covered with molten and transferred material.

**Figure 13. Hub with bearing cup of outboard wheel half**

**Figure 14. Hub with bearing cup of outboard wheel half, detail**

**Inboard wheel half**

The inboard wheel half showed severe damage caused BYR abrasion and fire. The part of the hub where the bearing cup is installed had been worn down to the position were the grease dam was installed. The inner bore with the bearing cup was completely worn out, the remaining part of the hub was damaged BYR fire. The outside circumference of the hub was covered with transferred material, formed to a conical shape. The transferred material contained steel remains of the bearing cup as well as aluminum from the hub itself. Cracks, particularly in the inner wheel half, are a fairly common initiation for wheel- and bearing failure. However, the visual inspection did not reveal evidence of cracking (pre-existing or as a failure mechanism). The channel type rotor drive keys showed mechanical damage on top due to impact and chafing as a result from contacting the brake rotor disks after bearing failure. The heat shield was dented near the rotor drive keys.

**Figure 15. Hub of inboard wheel half**

**Figure 16. Hub of inboard wheel half, detail**

**Figure 17. Damage to heat shield and rotor drive keys**

### Inboard wheel bearing

The inboard wheel bearing assembly had disintegrated. The inner race appeared to be in a relatively good condition without signs of overheat. It was labeled Timken nr. 596, which is the correct indication for this bearing. The cage was covered with soot, extensively deformed, and contained three damaged rollers.

**Figure 18. Inboard bearing inner race**

**Figure 19. Inboard bearing cage with rollers**

## Outboard wheel bearing

The outboard wheel bearing assembly had disintegrated; the inner race was deformed while exposed to excessive heat, which promoted plastic deformation. Two crushed rollers

were found stuck on the inner race. On the outer circumference of the inner race there were deep impressions caused BYR the bearing rollers, evidence of the high temperature present during deformation. The cage was ruptured; only the inner ring of the cage remained. No bearing identification number could be found.

**Figure 20. Outboard bearing inner race**

**Figure 21. Outboard bearing inner race (2)**

**Figure 22. Outboard bearing inner race, crushed rollers (3)**

**Figure 23. Outboard bearing cage**

**Figure 24. Bearing rollers, grease seal and clip ring**

### Axle nut and retaining ring

The axle nut showed discoloration due to high temperature and was deformed. The internal thread of the nut was damaged as well as a part of the outside circumference.


**Figure 25. Axle nut**

The retaining ring was deformed and extensively damaged. The locking key on the inside bore of the ring had sheared off. A small part of the key was still present on the ring. Discoloration and deformation indicated that the ring had been exposed to high temperatures.

**Figure 26. Retaining ring (1)**

**Figure 27. Retaining ring (2)**

**Brake assembly bolts and anti skid transducer**

No anomalies were found on the bolts of the number four brake assembly during visual examination. The anti skid transducer was damaged due to impact (off the aircraft) and overheating.

**Figure 28. Brake assembly bolts**

**Figure 29. Antiskid transducer (1)**

**Figure 30. Anti skid transducer (2)**

**Brake assembly**

The brake assembly was received in a partly disassembled condition. All disks where found removed from the unit and stored in a random order. Apart from damage caused BYR the incident the brake assembly appeared to be in a state which can be expected for an in service brake unit and that can be described as a normal condition. Damage found on the different parts of the assembly appeared to be gradual from inboard to outboard.

**Piston housing**

The piston housing had been cleaned before it was shipped to NLR-ATSI. However traces of soot were still visible on this part of the brake assembly. These traces were present on the aft half of the piston housing in relation to the direction of flight.

**Figure 31. Piston Housing**


**Figure 32. Piston with fire damage**

**Pressure Plate**

One half of the surface of the pressure plate was damaged BYR fire. This area of damage is consistent with the area found on the piston housing. Rotational damage to the lower area circumference was found.

**Figure 33. Pressure plate fire damage**

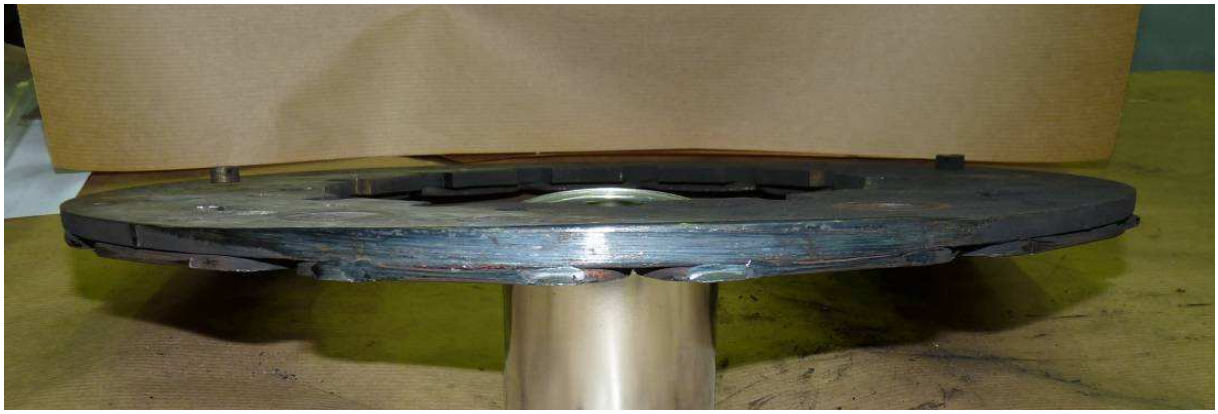


**Figure 34. Pressure plate rotational damage**

**Stator disks**

The stator disks were damaged on the lower segment of the outer circumference. This damage is consistent with the damage found on the rotor drive keys indicating that the wheel assembly was supported BYR the brake assembly. The lower linings were crumbled and lining material had crept in a downward direction.

**Figure 35. Damage to the lower segment of stator disk**

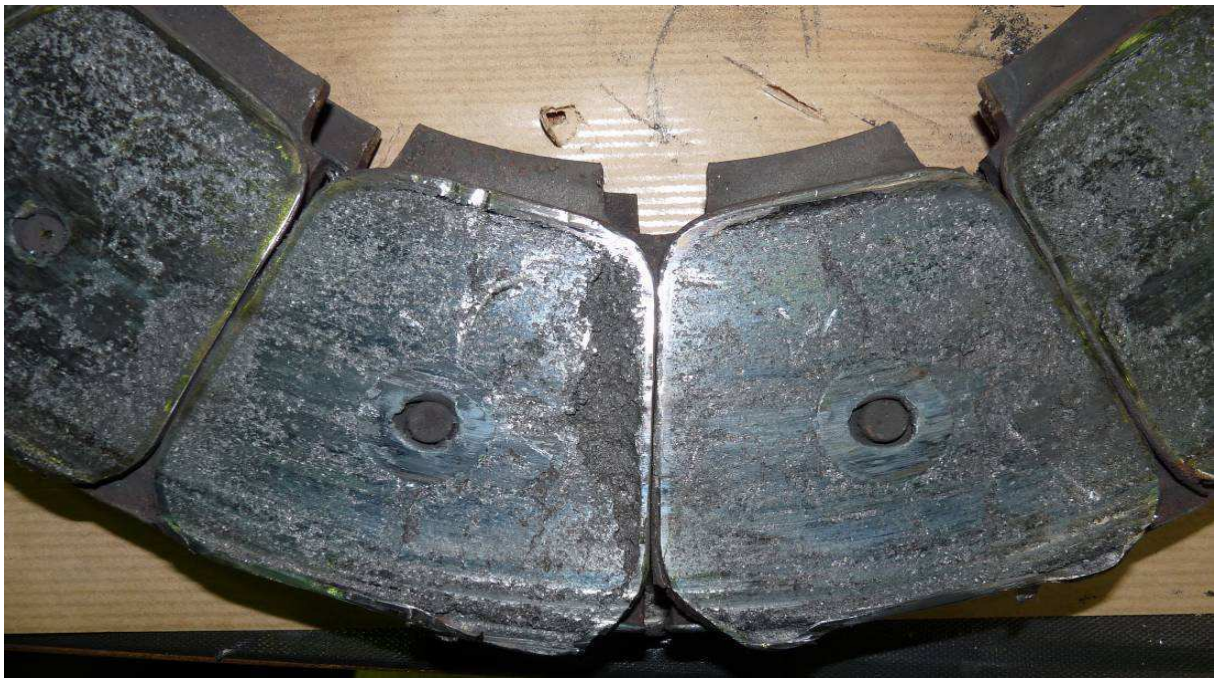


**Figure 36. Brake lining crumbling and creep**

**Rotor disks**

The surfaces of the rotor disks showed signs of normal wear. The inner disk circumferences were mechanically damaged due to contact with the torque tube of the brake assembly, indicating that the wheel assembly has been supported BYR the brake assembly. One disk contained a stuck rotor segment.

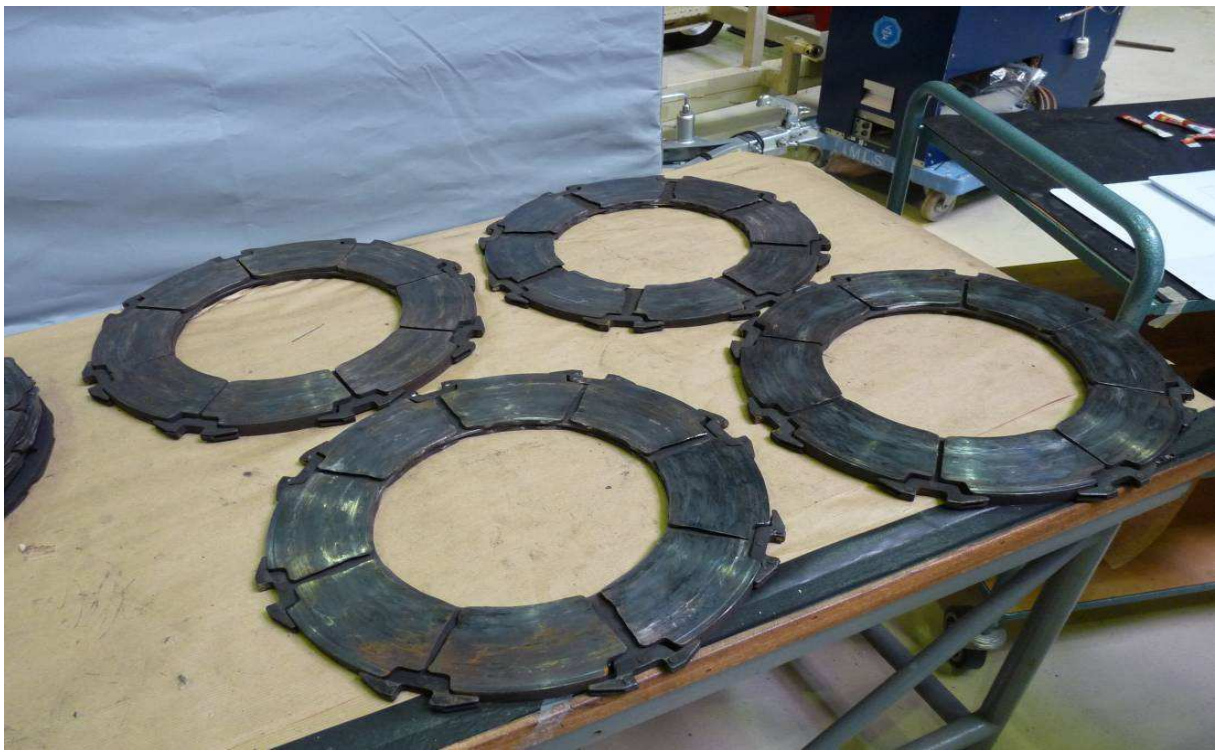


**Figure 37. Rotor disks overview**

**Figure 38. Damage to inner circumference of rotor disk**

## Torque tube assembly

The torque tube assembly was damaged in a number of locations. Discoloration and soot indicates that this assembly was exposed to fire. Mechanical and rotational damage was found on the lower splines. The indentations were consistent with the shape of, and damage found on, the rotor disks. The indentations found on one track of rotor disk differed from the others. This difference was caused BYR a stuck rotor segment on the affected disk. The lower segment of the outer circumference of the backing plate was found damaged due to interaction with the rotor drive keys on the inboard wheel half. A small part of the top segment of the outboard inner bore of the torque tube contained transferred material from the inner wheel half and inboard bearing. This damage and the shape of the inner bore was consistent with the damage found on the hub of the inboard wheel half.

**Figure 39. Torque tube assembly spline damage**

**Figure 40. Difference in indentation caused BYR stuck rotor segment**

**Figure 41. Torque tube outboard side**

**Figure 42. Transferred material**

### 1.16.3. Maintenance history

The maintenance history of the main wheel assembly was available for analysis. No irregularities were found that could have been of influence on this incident. The maintenance records of the wheel assembly indicated the following:
Date overhaul: October 2007
Number of tire changes since overhaul: 2
Date installed on YL-BBE: September 10 2008
Time since installation: 919 hrs
Cycles since installation: 584
Total time: 11030 hrs
Total cycles: 5662

### 1.16.4. Metallurgical examination

The axle nut was subjected to metallurgical examination. Objective of this examination was to determine if maintenance was a factor in the possible bearing failure; effectively if an over-torque condition occurred during installation. Three cross sections were made in order to determine a shear direction of the internal thread. Examination of the axle nut cross sections did not lead to unambiguous evidence that the internal thread had sheared in one direction, meaning that there was no obvious indication for over-torque.


**Figure 43. Cross sections on axle nut**

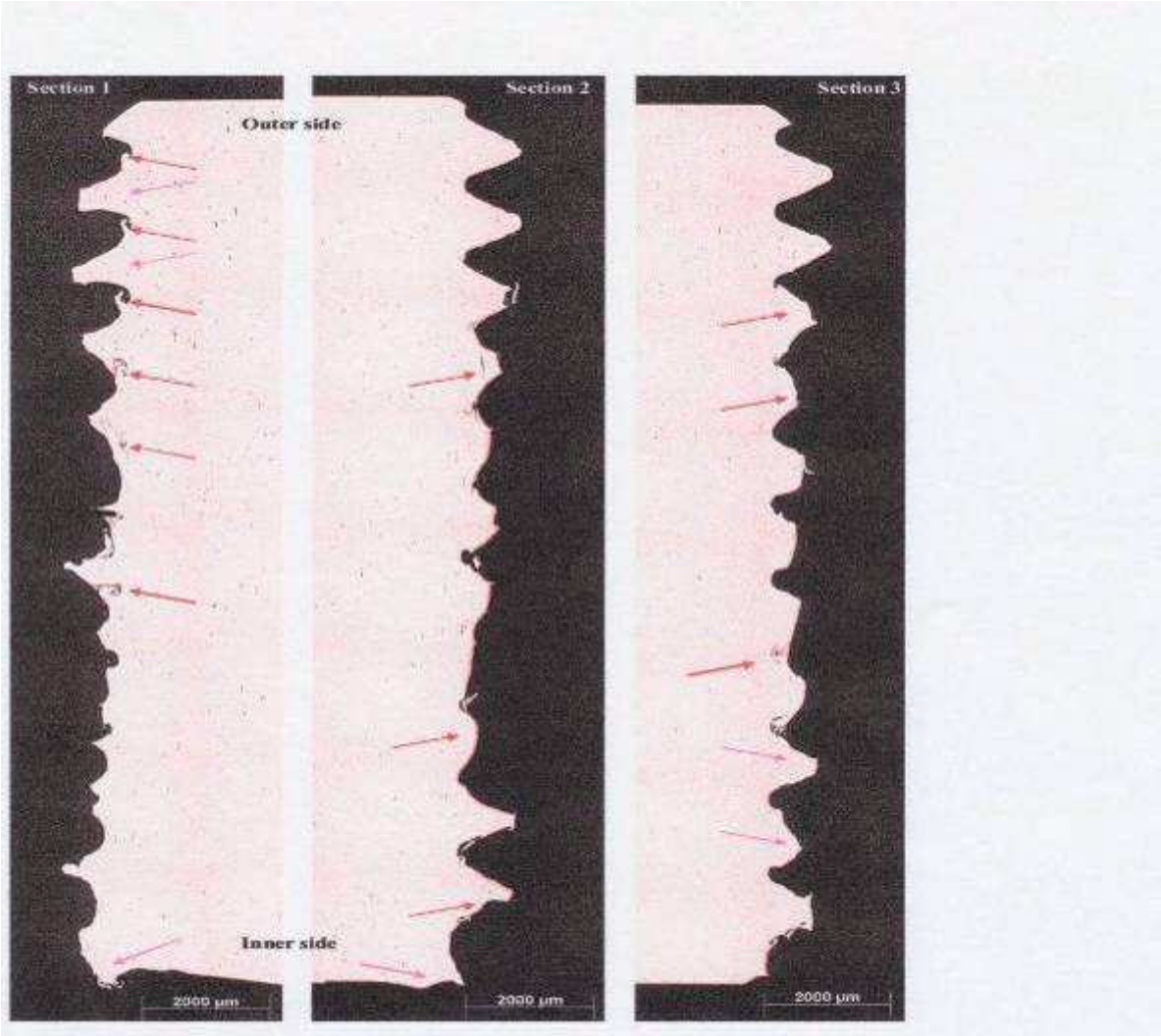



**Figure 44. Shear direction indicators in the three cross sections**

## 1.17. Organizational and management information

In the Air Baltic Operational Manual Part A is determined that - Commander shall notify MCC and nearest authority by the quickest means available of any Accident or Serious incident, but not determined the procedures to inform the ATC of departure airport about loosing some parts of the aircraft on the runway during the take off, what is very important to flight safety.

## 1.18. Additional information

Boeing has received reports of landing gear wheel damage/loss and damage or fracture of the landing gear axle. These occurrences have often been attributed to wheel bearing failures. Examination of failed bearings has found that the actual cause of the bearing's failure could not be established due to the extent of the secondary damage that occurs as the wheel continues to rotate with a damaged bearing. In some cases, when a wheel has departed the airplane, the wheel's outer bearing has failed, allowing the wheel to migrate off the axle. In these cases, the axle nut and lock washer have remained on the axle. In some wheel loss instances, the axle fractured due to an inner bearing failure.

**In some cases, the following causes and contributing factors have been identified:**

**1) Installation of the wrong wheel bearing part number on the wheel half:**

It has been reported that wheel bearings from other airplane models (Boeing and non-Boeing) of similar size, have been inadvertently installed into wheel halves not intended to have that particular bearing part number installed. In response to these reported cases of incorrect bearing part number installation, Boeing issued Fleet Team Digest articles (FTD's) for many models highlighting the importance of verifying that the proper inboard and outboard wheel bearing part numbers are installed in the correct wheel half. See reference (a) as an example. Both Honeywell and Goodrich have issued service letters that are applicable to all of their equipment regarding this subject. In the case of the 737 nose gear wheels, Goodrich, Honeywell, and Dunlop have also issued specific service letters for this application to highlight this concern due to the similarity in the bearing part numbers and bearing sizes that can b e inadvertently installed in these wheels.

**2) Contamination with water:**

In several cases, it has been determined that the bearing lubricant had been contaminated with water, possibly as a result of pressure washing fluid directed at the wheel bearings. This item is more applicable to nose wheels since most nose wheels do not have hubcaps that protect against water ingress.

**3) Short term and long term airplane storage:**

Airplanes that have very low utilization often experience higher numbers of wheel bearing failures due to condensation. It is theorized that moisture condenses in the bearing area and if this moisture is left for a prolonged period of time, it can cause severe corrosion on the bearing surfaces. If an airplane is used frequently, it appears that significant corrosion does not occur, perhaps due to normal operating temperatures of the bearing or perhaps due to the grease being continually spread though the bearing surfaces. Operators should review the short term and long term storage procedures regarding landing gear wheels contained in the in the applicable chapter 10 section of the Airplane Maintenance Manual (AMM). The reference (b) FTD article provides more details regarding this issue.

**4) Incorrect wheel spacer and axle washer installation:**

Some airplane models have wheel spacers and axle washers. In several cases, it has been found that the wheel spacer and/or axle washer was inadvertently omitted or mis-installed during the removal and replacement of a wheel and tire assembly.

**5) Inadequate and improper lubrication of the wheel bearing:**

Insufficient quantity of wheel bearing grease, incorrect type of grease, or contaminated grease can cause a bearing to fail.

**6) Incorrect axle nut torque:**

Incorrectly applied axle nut preload torque (axle nut torque too high or too low) can cause wheel bearings to fail very quickly. It is necessary for the bearing’s cone to seat inside the bearing’s cup prior to initial operation of the wheel bearing. Application of the proper axle nut preload torque documented in the AMM provides the force needed to seat the cone inside the cup.

**7) Incorrect axle nut installation:**

Several reports have been received that the axle nut, axle nut washer, or locking device for the axle nut was incorrectly installed. For example, Boeing has received some reports of axle nut retaining bolt/nut loosening and/or loss on various airplane models over the

past 30+ years. In most of these cases, excessive reuse of the lockbolts and locknuts is believed to have been the root cause. Omission of the bolt/nut during axle nut installation is also a possible cause. If both retaining bolts back out, the axle nut may loosen, resulting in a decrease of wheel bearing preload. This preload decrease can cause wheel bearing damage/failure and loss of the wheel assembly. On some models, the axle thread may have been repaired by reducing the thread size. This reduced axle thread size requires the installation of a special axle nut with threads of the same size. The repaired axle and the special nut should be clearly labeled that they need to be matched together. Operators must ensure repaired axle threads use the corresponding axle nut because inadvertent installation of the wrong axle nut size can cause the wheel to migrate off the axle during takeoff or landing.

**8) Installation of a rejectable condition bearing:**

Wheel bearings require very detailed examinations at each wheel shop visit to ensure serviceability. Refer to the applicable wheel manufacturers Component Maintenance Manual (CMM) for acceptable wheel bearing criteria.

**9) Defective wheel bearing:**

It is possible that a wheel bearing may be defective or have a manufacturing flaw. However, this is very difficult to prove after the extensive secondary mechanical damage that occurs after the bearing has failed.

**10) Loose bearing cups:**

The wheel bearing's cup can migrate or become loose and rotate inside the wheel's hub due to a lack of adequate interference fit. This condition can be difficult to detect if not checked regularly during wheel overhaul shop inspections. It is important that the proper interference fit be established between the bearing cup and wheel's hub per the wheel manufacturer's CMM. Most of the above items can be averted by careful and thorough maintenance techniques documented in the applicable wheel manufacturer's CMM.

### 1.19. Useful or effective investigation techniques

Not applicable

## 2. ANALYSIS

### 2.1. Summary of findings

Investigation of the available parts showed severe damage to the outboard bearing assembly, the axle nut and the retaining ring as well as the inboard hub of the wheel assembly.

A high temperature condition as a result of friction has occurred at the outboard bearing assembly, axle nut and retaining ring.

Despite the damage found to the inboard bearing assembly and the damage found on the inboard wheel hub, the inner race and the cage with remaining three rollers were found in a relatively good condition. This is an indication that the inner bearing was intact at wheel separation, and was not instrumental in the failure of the assembly.

No evidence was found of pre-existing cracks or cracking as a bearing failure initiation mechanism on the inner wheel hub.

Evidence of fire was found on the inboard wheel hub and the outboard side wall of the tire. This indicates that a fire existed at the inboard wheel hub and that the flames were drawn through the openings between the spokes to the outboard part of the wheel assembly.

The conical shape of the transferred material found on the outside circumference of the inboard wheel hub indicates that there has been extensive friction contact between the wheel assembly and the brake unit due to lateral movement of the wheel assembly.

The damage found on the brake disks, the torque tube and the rotor drive keys on the inboard wheel half indicates that the wheel assembly has been supported by the brake assembly.

Damage to the threads of the axle did not unambiguously indicate an over-torque situation.

## 2.2. Scenario

The most plausible sequence of events which led to the separation of the number four main outboard wheel assembly is the following:

Failure of the outboard bearing resulting in a high temperature condition due to rotational friction between bearing and shaft.

Disintegration of outboard bearing caused axial play on the wheel installation resulting in damage to the inboard bearing.

Due to the failure of both bearings the wheel assembly was able to shift and was forced in a lateral direction towards the brake assembly, while supported by the brake disks on the inboard side and the remains of the outboard bearing, retaining ring and axle nut on the outboard side.

Due to the friction-generated heat caused by the inboard hub rubbing against the brake assembly a fire was initiated.

Due to disintegration of the outboard wheel bearing the wheel assembly was able to separate from the shaft at the moment the acting loads on the wheel were reduced at lift off.

## 2.3. Outer bearing failure

The direct cause of the failure of the outer bearing could not be determined, due to the amount of mechanical damage done to the bearing assembly and the surrounding parts of the wheel assembly.

Boeing service letter 737-SL-32-149 contains a comprehensive list of possible causes of bearing failure, which will be discussed in this paragraph with an indication whether a specific cause could be applicable in this case. The cause-numbering is according to that in the service letter.

1) Installation of the wrong wheel bearing part number on the wheel half. During the visual inspection where possible part numbers were checked against the appropriate part lists. The inner bearing was found to probably be the correct one, based on the number found on the inner race. No identification could be found on the outer bearing inner race. However, the assembly had several hundred cycles and would probably have failed much earlier if a wrong bearing part had been installed. This cause is considered to be unlikely.
2) Contamination with water. In this case bearing lubricant is contaminated with water, reducing its lubricating properties, causing the bearing to fail. The state of the outer bearing prevented any possible drawing of conclusions in this respect. Main wheels are less susceptible to water contamination than nose wheels because of the protection the hub caps offer, but it can not be ruled out. This cause is considered possible, among a number of others.
3) Short term and long term airplane storage. There is a link between low utilization of airplanes, moisture condensation and wheel bearing failures. Considering the history of the aircraft/wheel combination, this cause is considered unlikely.

4) Incorrect wheel spacer and axle washer installation. All essential parts of this part of the wheel/bearing assembly were present, except the axle nut retainer ring. The washer locking tooth was found sheared off, but still in the axle groove, an indication for correct installation. Measurement during the initial investigation on the aircraft indicated a correct position of the nut and washer at the moment of failure. This cause is considered unlikely, but remotely possible.
5) Inadequate and improper lubrication of the wheel bearing. Insufficient, incorrect or contaminated grease can not be ruled out, and is considered a possibility.
6) Incorrect axle nut torque. Incorrect torque (too high or too low) can cause bearings to fail. Investigation of the nut did not show conclusive evidence of overtorque. Furthermore, an under- or overtorqued wheel would probably have led to an earlier failure. However, both over- and undertorque are considered possible causes.
7) Incorrect axle nut installation. The axle nut was present, and at its approximate correct position when the bearing failed (see item 4). There is no indication of the nut loosening. This cause is considered unlikely, but not impossible.
8) Installation of a rejectable condition bearing. The condition of the outer bearing on assembly could not be established. This cause is considered possible.
9) Defective wheel bearing. See item 8. It was not possible to determine any preexisting faults in the bearing. This cause is considered possible.
10) Loose bearing cups. The cup of the outboard bearing was (partly) present in the outboard wheel half, and did not show signs of rotation. This cause is considered improbable.

To summarize: a large number of causes can not be ruled out, or can not be ruled out completely. However, the assembly functioned correctly for several hundred cycles, so blatant installation errors like wrong bearings or missing parts are less plausible.

## 3. CONCLUSIONS

The following conclusions can be drawn based on the investigation of wheel assembly Bendix H40X14.5-19 with serial number B0133.

The wheel assembly was mechanically in a reasonable in-service condition.

The wheel bearings were severely damaged and have been exposed to a very high temperature.

The fire and high temperature conditions existed for a brief period of time.

The eventual wheel separation was initiated by the failure of the outboard bearing.

The direct cause of the outboard bearing failure could not be determined.

**Possible reasons for failure are:**

- incorrect installation,
- insufficient lubrication,
- bearing contamination, or
- a rejectable or defective bearing.

None of these causes can be ruled out.

No evidence of excessive torque on the axle nut was found.

## 4. FLIGHT SAFETY RECOMMENDATIONS

**It is recommended to the Supervisory Authority Latvian CAA to establish in Operation Manuals Part A of "Air Baltic" and Operation Manuals of all commercial airlines of Latvia the following procedure:**

**Recommendation - 14-2009**

In case when some parts of the aircraft are to separate and to be missing (remain) on the runway during the take off the crew should immediately inform the ATC of the departure airport.

**Based on the analysis discussion it is recommended that the following Maintenance recommendations to Air Baltic Technical Operations are provided to help prevent the similar wheel bearing failures and wheel losses from occurring in the future:**

**Recommendation - 15-2009**

Ensure that the correct bearing part number is installed in the correct wheel half.

**Recommendation - 16-2009**

Ensure that the correct axle nut tightening procedures are used and that wheel spacers, axle nut, axle nut washer, and axle nut retention devices are correctly installed per the applicable AMM procedure.

**Recommendation - 17-2009**

Verify that the wheel bearings are carefully examined for rejectable conditions at each shop visit of the wheel assembly. The wheel manufacturer's CMM's and Timken (the wheel bearing manufacturer) publish detailed examination guidelines. Some wheel suppliers have posters that illustrate rejectable and acceptable wheel bearing service conditions. Special attention should be given to the condition of the roller ends and cone's large rib faces. These areas should always be inspected to determine if there is any scoring damage. Any bearing with scoring on the rollers or cage ribs should be removed from service.

**Recommendation - 18-2009**

Ensure that the wheel bearing is free of water, contaminants, and cleaning fluids before packing them with grease and re-pack the bearing with generous amounts of proper new and clean grease using an approved packing method. Mechanical grease packing devices are preferred. Bearings should be fully packed with an emphasis on grease under the cage and between the rollers.

**Recommendation - 19-2009**

Check the wheel bearing cup for migration inside the wheel half's hub or signs that the cup is rotating at every tire change.

**Recommendation - 20-2009**

Protect the wheel bearings with suitable covers to prevent dust and moisture ingress during transportation and storage of the wheel assembly.

**December 18, 2009**

Director of Transport Accident and
Incident Investigation Bureau Ivars Alfreds Gaveika