Technical report

IN-019/2022

Incident on 31 March 2022 involving a Boeing 737-8AS aircraft operated by Ryanair, registration EI-DLC, at Adolfo Suárez Madrid-Barajas Airport

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GOBIERNO DE ESPAÑA
MINISTERIO DE TRANSPORTES Y MOVILIDAD SOSTENIBLE
SUBSECRETARÍA
COMISIÓN DE INVESTIGACIÓN DE ACCIDENTES E INCIDENTES DE AVIACIÓN CIVIL

FOREWORD

This report is a technical document that reflects the point of view of the Civil Aviation Accident and Incident Investigation Commission regarding the circumstances of the accident that is the object of the investigation, its probable causes, and its consequences.

In accordance with the provisions of Article 5.4.1 of Annex 13 of the International Civil Aviation Convention, Article 5.6 of Regulation (EU) No 996/2010 of the European Parliament and of the Council of 20 October 2010; Article 15 of Law 21/2003 on Air Safety; and Articles 1 and 21.2 of RD 389/1998, this investigation is exclusively of a technical nature, and its objective is the prevention of future aviation accidents and incidents by issuing, if necessary, safety recommendations to prevent their recurrence.

The investigation is not intended to attribute any blame or liability, nor to prejudge any decisions that may be taken by the judicial authorities. Therefore, and according to the laws specified above, the investigation was carried0 out using procedures not necessarily subject to the guarantees and rights by which evidence should be governed in a judicial process.

As a result, the use of this report for any purpose other than the prevention of future accidents may lead to erroneous conclusions or interpretations.

This report was originally issued in Spanish. This English translation is provided for information purposes only.

CONTENTS

ABBREVIATIONS

°	Degrees
AAIB	Air Accidents Investigation Branch of the United Kingdom
AOC	Air Operator Certificate
ATPL(A)	Airline transport pilot license
CMM	Component maintenance manual
CPL(A)	Commercial pilot license
CVR	Cockpit voice recorder
FDR	Flight data recorder
ft	Feet
g	Gravitational acceleration.
h	Hours
hPa	Hectopascals
IAA	Irish Aviation Authority
IFR	Instrument flight rules
kg	Kilos
km	Kilometres
kt	Knots
METAR	Aviation routine weather report (in aeronautical meteorological code)
N1	Speed of the low-pressure compressor
NTSB	National Transportation Safety Board of the United States
ICAO	International Civil Aviation Organisation.
QAR	Quick access recorder
UK	United Kingdom
UTC	Coordinated universal time

Technical report IN-019/2022

Owner and operator:	Ryanair.
Aircraft:	BOEING 737-8AS, EI-DLC (Ireland).
Date and time of incident:	31 March 2022, at 21:40 UTC[1].
Site of accident:	M25 taxiway at Adolfo Suárez Madrid-Barajas Airport.
Persons on board:	6 (crew members), 153 (passengers).
Type of operation:	Commercial air transport - Scheduled - International - With passengers.
Phase of flight:	Taxi from runway.
Flight rules:	IFR.
Date of approval:	19 December 2023.

SYNOPSIS

Summary:

On Thursday, 31 March 2022, at 21:33 h, a Boeing 737-8AS aircraft with registration EI-DLC, operated by Ryanair, landed on runway 32R at Adolfo Suárez Madrid-Barajas Airport coming from Brindisi Airport (Italy).

While taxiing from the runway to the apron, the left wheel hub on the left main landing gear failed, and the aircraft came to a standstill on the M25 taxiway.

As a result of the fractured wheel, the aircraft could not move or be towed, which meant that the wheel had to be replaced on the taxiway.

After the wheel had been replaced, the aircraft was towed to a parking stand at the airport.

Nobody was injured.

The investigation has concluded that the incident was caused by a fracture in the hub of the inner wheel half of the left wheel on the aircraft's left main landing gear due to the propagation of a fatigue crack originating from a corrosion pit.

The fact that the instructions for the major overhaul of the wheel contained in CMM revision 10 (in force on the day of the incident) were not enough to ensure the integrity of the wheel during its service life is thought to have been a contributing factor.

No safety recommendations are issued.

[1] Unless otherwise indicated, all times referenced are UTC. The equivalent local time can be calculated by adding 2 hours to the UTC.

1. FACTUAL INFORMATION

1.1. History of the flight

On Thursday, 31 March 2022, at 21:33 h, a Boeing 737-8AS aircraft with registration EI-DLC, operated by Ryanair, landed on runway 32R at Adolfo Suárez Madrid-Barajas Airport coming from Brindisi Airport (Italy).

The landing was executed with automatic braking and reverse thrust at idle.

According to the information gathered, the first officer, who was acting as pilot flying during the landing, did not notice anything unusual in terms of the performance of the aircraft during the landing rollout.

While the aircraft was still taxiing on runway 32R at about 80 kt, the captain took over the aircraft controls and gently applied the brakes (which deactivated the automatic braking) in order to take the first exit taxiway from runway 32R (exit taxiway K5).

On leaving the K5 exit taxiway to join the KA4 taxiway, the captain noticed that the aircraft was decelerating more than usual, so he applied thrust to the engines.

As it continued the taxi via taxiways KC and M27, the crew noted that, given the aircraft's weight and the external conditions, its speed was not consistent with the thrust level of the engines (according to the crew, the taxi speed was only 18 - 20 kt with a thrust level of 40% on both engines). Despite this, all the cockpit readings were normal.

After concluding that the aircraft was experiencing abnormal drag, the crew closed the throttle, and the aircraft came to a rapid stop without the need to brake on the M25 taxiway.

Subsequently, at around 21:40 h, the crew contacted Ryanair personnel to explain the situation.

At around 22:16 h, Ryanair personnel arrived at the aircraft and, after asking the crew to shut down the engines, approached it to inspect the landing gear.

The visual inspection by Ryanair personnel revealed that the left wheel on the left main landing gear was misaligned and touching the brake body, making it impossible to move the aircraft without replacing the wheel.

One hour and forty minutes after the crew contacted Ryanair staff to inform them of the situation, the passengers were disembarked and transferred in buses to Terminal 1. The crew left the aircraft while Ryanair staff were still working on it at 23:40 h. They were also taken to Terminal 1.

The repair work was completed at 23:50 h, and the aircraft was towed to a parking stand at the airport.

There were no injuries.

1.2. Injuries to persons

Injuries	Crew	Passengers	Total in the aircraft	Others
Fatal	-	-	-	-
Serious	-	-	-	-
Minor	-	-	-	-
Unharmed	6	153	159	-
TOTAL	6	153	159	-

1.3. Damage to aircraft

The hub of the inner wheel half of the left wheel on the aircraft's left main landing gear fractured, causing additional damage to various parts of the wheel and the brake.

1.4. Other damages

There were no further damages.

1.5. Personnel information

- Captain:

On the day of the incident, the captain was 32 years old.

He had an airline transport pilot license (ATPL) with a B737 300-900 type rating, valid until 31 March 2023.

He also had a Class 1 medical certificate, valid until 30 September 2022.

He completed his initial training on 5 June 2013 and the captain's training on 31 March 2017.

His total experience was 6810 hours with 6612 hours in type.

- First officer:

On the day of the incident, the first officer was 43 years old.

He had a commercial pilot license (CPL) with a B737 300-900 type rating, valid until 31 December 2022.

He also had a Class 1 medical certificate, valid until 13 September 2022.

He completed his initial training on 31 December 2018.

His total experience was1999 h, of which 1798 h were in type.

1.6. Aircraft information

1.6.1. General aircraft information:

- Make: BOEING.
- Model: 737-8AS.
- Year of manufacture: 2005.
- Serial number: 33586.
- Maximum take-off weight: 66990 kg[2].
- Maximum landing weight: 65317 kg[3].
- Type of engine: CFM56-7B26/3.
- Information about the operator: Ryanair.

The BOEING 737-8AS aircraft with registration EI-DLC and serial number 33586 is a short to medium-range passenger transport aircraft powered by two turbofans.

The aircraft had a certificate of registration and an airworthiness certificate issued in 2014 and 2008, respectively, by the Irish Aviation Authority (IAA).

The aircraft's airworthiness review certificate was valid until 4 December 2022 (second extension).

At the time of the incident, the aircraft had accumulated 49866:54 flight hours and 29592 cycles.

1.6.2. Information about the aircraft's landing gear:

The BOEING 737-8AS aircraft has a retractable tricycle-type landing gear. Each of the two main landing gear legs has two wheels, which can rotate independently.

The main landing gear wheels consists of two wheel-halves (inner and outer) bolted together. The hub of each wheel half houses a tapered roller bearing.

In addition, each of the main landing gear wheels has a differential-type hydraulic braking system. The wheel brake pack is positioned within the inner wheel half.

[2] Value obtained from the registry of the Irish Aviation Authority (IAA).
[3] Value obtained from RYANAIR.

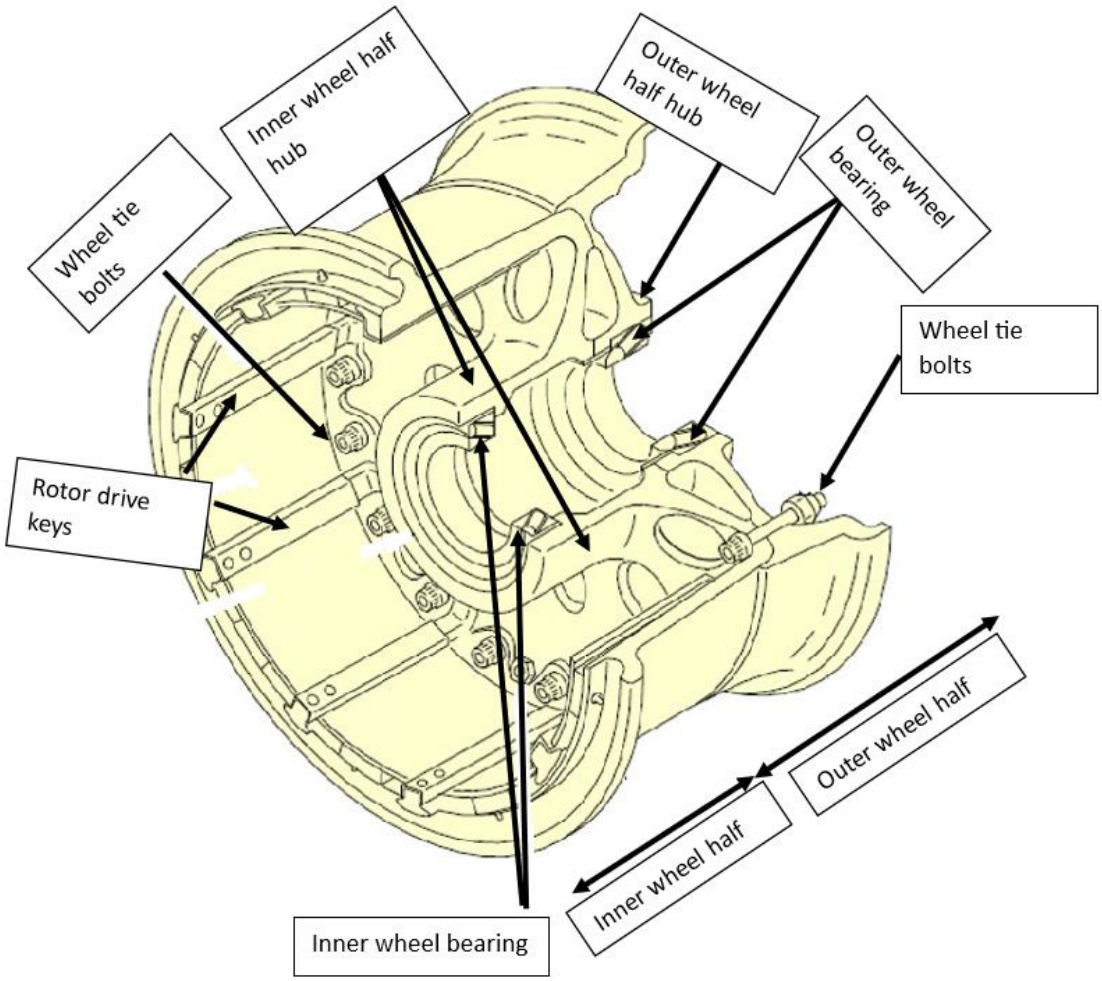

Figure 1 – Sketch of the BOEING 737-8AS wheel.

1.6.3. Information relating to the maintenance guidelines provided by the wheel manufacturer (Honeywell) in regard to the major overhaul:

The following information on the major wheel overhaul, which is considered relevant to the investigation, has been extracted from the CMM revision 10 produced by Honeywell (in force on the day of the incident):

- As a general rule, a major wheel overhaul is required every 24 months or 1800 cycles.
- The following maintenance task is of note as it involves the inspection of an area very close to the one in which the fracture originated (see figure 7). It requires non-destructive testing of the internal bearing bore in the hub of the inner wheel half:
    - NDT inspection of the inner and outer wheel halves (code 32-40-14-000-025-A01): When the bearing cup or bearing cup and sleeve assembly is removed from wheel half, use eddy current, ultrasound, or fluorescent penetrant inspection to examine the bearing bore inside diameter and corner radius for possible indications. This should be carried out during

every tyre change and major overhaul if and only if the bearing cup is removed from the wheel half[4].

1.6.4. Information about the fractured wheel:

The fractured wheel (P/N 2612311-1 and S/N B13557) was manufactured in 2008 and, as of the day of the incident, had flown 10,996 cycles.

Since being installed on the aircraft on 13-01-2022 after a major overhaul performed on 07-01-2022 at the wheel manufacturer's facility in Feltham (England, UK), it had flown 229 hours and 148 cycles. This major overhaul was carried out in accordance with CMM revision 10.

As part of said major overhaul, the following tasks were carried out:

- Inspection of the inner and outer parts of the wheel halves, including an inspection of the hubs, which, in turn, included an ultrasonic inspection of the bearing bore radius.
- Eddy current inspection of the inner and outer parts of the wheel halves.
- Fluorescent penetrant inspection of the inner and outer parts of the wheel halves.
- Visual inspection of the bearing cups.
- Inspection of other small parts (nuts, washers, tie bolts, bearings, valves, seals, etc.).

It should be noted that during the aforementioned major overhaul, the bearing cup was not removed from the hub of the inner wheel half. Consequently, the previously specified task no. 32-40-14-000-025-A01 was not carried out during the major overhaul.

1.7. Meteorological information

The METAR for Adolfo Suárez Madrid-Barajas closest to the time of the incident was as follows:

METAR LEMD 312130Z 31005KT 280V010 9999 FEW055 SCT070 09/05 Q1007 NOSIG

- Date and time: 31 March 2022; 21:30 UTC.
- Wind: Speed 5 knots. Predominant direction 310º. Variable direction between 280º and 10º.
- Visibility: Greater than 10 km.
- Clouds: Few clouds with base at 5500 ft (1st layer). Scattered clouds with base at 7000 ft (2nd layer).

[4] As the wheel manufacturer indicated, standard visual inspections of the bearing cup and non-destructive testing of the hub form part of the major overhaul. Unless the result of any earlier inspections requires it, the bearing cup is not removed from the hub.

- Temperature: 9 ºC.
- QNH: 1007 hPA.
- Absence of significant changes during the forecast period.

Therefore, the weather conditions did not place any limitations on the operation.

1.8. Aids to navigation

N/A.

1.9. Communications

N/A.

1.10. Aerodrome information

Adolfo Suárez Madrid-Barajas Airport is located northeast of the city of Madrid, at an elevation of 1998 ft above sea level.

The airport has four parallel runways arranged side by side.

The incident occurred on the M25 taxiway, which is located adjacent to the apron of terminal T4S.

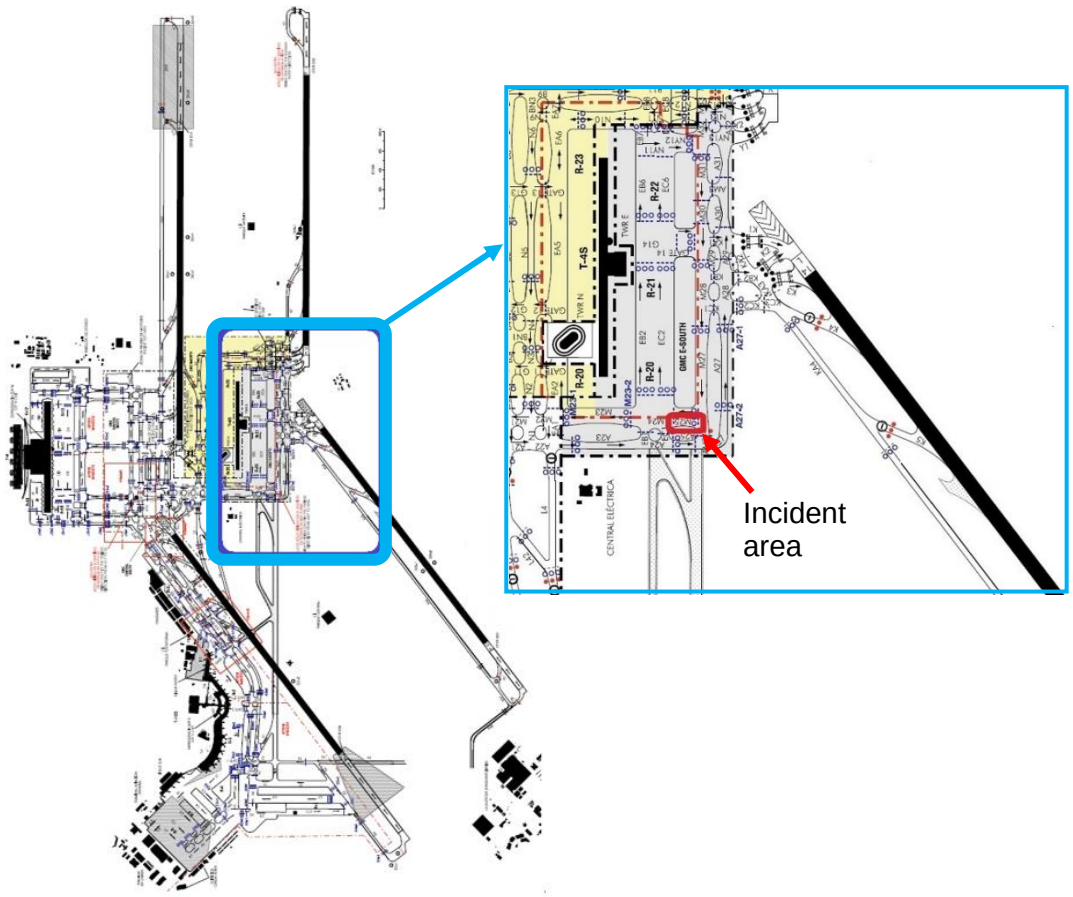

Figure 2 - Map of Adolfo Suárez Madrid-Barajas Airport and area of the incident.

1.11. Flight recorders

Neither CVR nor FDR data was available as it had already been recorded over by the time it was requested.

However, the data recorded by the QAR was provided by the operator.

The most relevant information is shown below:

- No notable data was observed in regard to the parameters recorded during taxi and take-off at the airport of origin.
- The take-off weight of the aircraft was 66700 kg.
- The weight of the aircraft on landing was 60000 kg.
- The vertical acceleration of the aircraft on landing was +1.2 g.
- The aircraft landed at a speed[5] of approximately 135 kt. The spoilers and reverse thrust were deployed (at idle). Automatic braking was also activated.
- The aircraft departed the runway on exit taxiway K5 (with automatic braking off) at a speed of approximately 48 kt.
- The aircraft travelled along exit taxiway K5 and joined taxiway KA4. While taxiing on this taxiway, its speed was 16 kt, and the N1 of the engines was approximately 35%. The brakes were not applied at any time.
- The aircraft turned onto taxiway KC at a speed of 9 kt with the N1 of the engines at approximately 40%. As the aircraft travelled along KC, it reached a maximum N1 of 42% and a speed of 11 kt.
- The aircraft turned to join taxiway M27. The turn was carried out at a speed of 10 kt, with N1 at 37%.
- While the aircraft was taxiing on M27, it reached a maximum speed of 16 kt with N1 at 37%.
- The aircraft turned to join taxiway M25. Its speed on entering the turn was 9 kt, and it slowed during the turn to 4 kt. As the speed reduced, the N1 increased to 39%.
- During the taxi on M25, the aircraft's speed did not exceed 2 kt, and the N1 of the engines was almost 40%. The aircraft came to a final stop on this taxiway.

The following figure shows the path followed by the aircraft based on the above data:

[5] All speeds mentioned in this section are speeds relative to the ground.

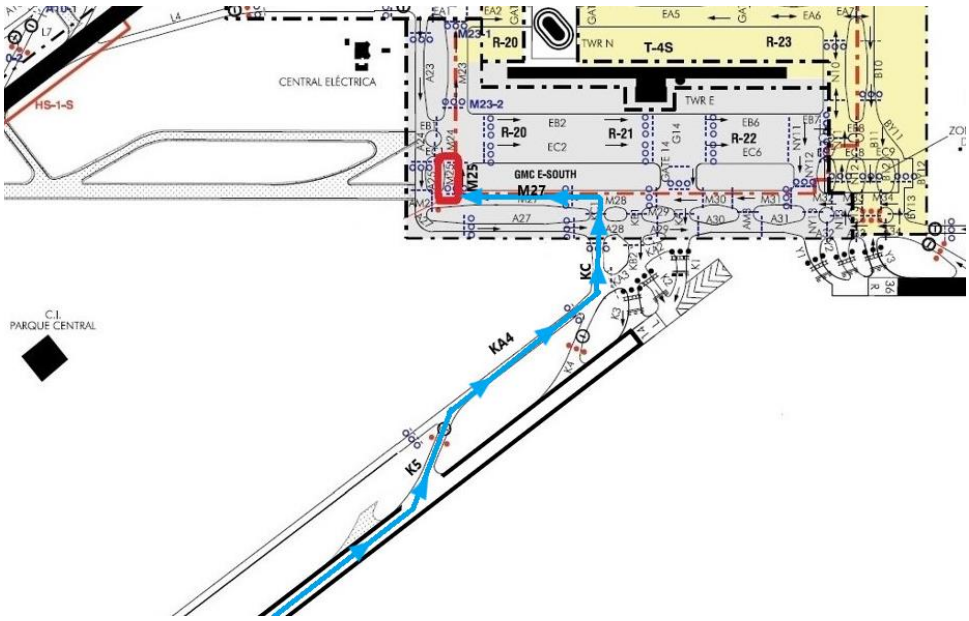

Figure 3 - Aircraft's taxi through Adolfo Suárez Madrid-Barajas Airport.

1.12. Aircraft wreckage and impact information

The aircraft came to a standstill on taxiway M25 at Adolfo Suárez Madrid-Barajas Airport due to the fracture of the left wheel on the left main landing gear. The fracture made it impossible to move the aircraft, either under its own power or by tow, which meant that Ryanair personnel had to replace the wheel on the taxiway.

Following the work to replace the damaged wheel, the Ryanair staff at Madrid submitted a report (engineers special report) into the Ryanair internal safety management system specifying the work carried out on the aircraft while it was on the taxiway and the anomalies found.

The most relevant information in that report was as follows:

- The left wheel on the left main landing gear was misaligned and interfering with the brake.
- The left wheel on the left main landing gear was removed. The hub of the inner wheel half was completely destroyed: part of it remained attached to the wheel half and the other part had broken off in several fragments.
- There was considerable damage to the brake.
- No damage was found in the wheel axle, nut or washer.

In addition, the following photographs were provided, taken immediately after the incident by Ryanair personnel during the wheel replacement work:

Figure 4 - Left main landing gear.

Figure 5 - Exterior and interior of the affected wheel.

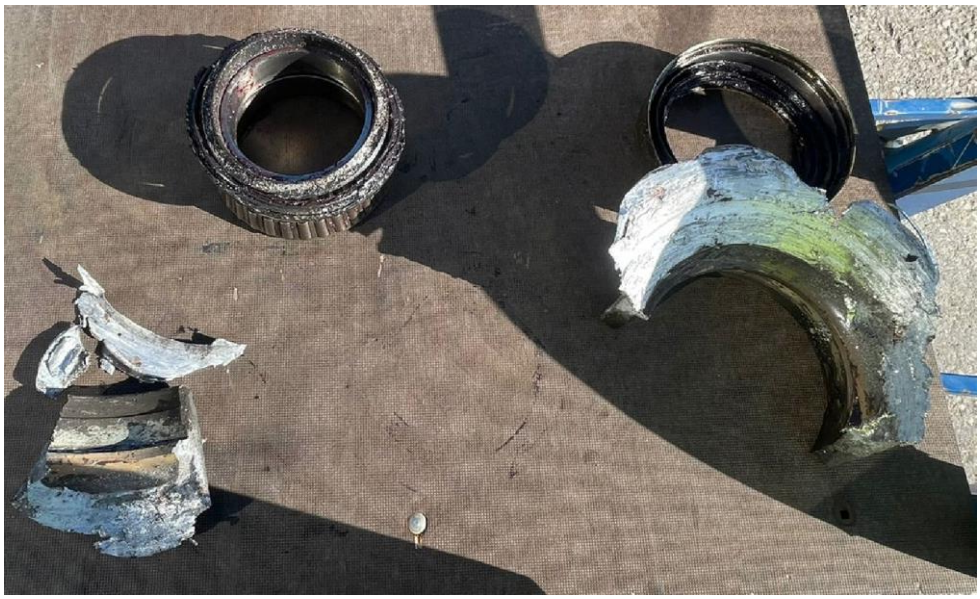

Figure 6 - Associated fractures to the affected wheel.

Figure 4 shows that the left wheel was misaligned in relation to the right wheel.

Figure 5 shows the condition of the inner wheel half and the outer wheel half. The part of the hub that remained attached to the wheel half can be observed.

Figure 6 shows the part of the hub of the inner wheel half that detached from the wheel (broken into several fragments), as well as the inner wheel bearing and its cup.

1.13. Medical and pathological information

N/A.

1.14. Fire

There were no signs of an in-flight fire.

1.15. Survival aspects

N/A.

1.16. Tests and research

The wheel manufacturer conducted a study of the fracture and concluded the following:

- The study identified several radial and circumferential fractures in the hub fragments from the inner wheel half.
- The primary fracture was caused by a fatigue crack originating from one corner of the chamfer between the bearing bore and the sealing surface on the hub of the inner wheel half. The analysis of the area in which the crack originated revealed the existence of corrosion. Said crack was identified on the surface of one of the radial fractures.
- Signs of overload fracture were found on the surface of the other radial fractures and on the surface of the circumferential fractures.
- Both the inner and outer bearings were able to rotate freely and appeared almost completely undamaged.
- A second developing crack was detected in another section of the hub of the inner wheel half. Laboratory work determined that this developing crack had the same origin and propagated in the same way as the crack that caused the primary fracture.

The figure below contains a sketch of the wheel showing the area in which the fracture originated:

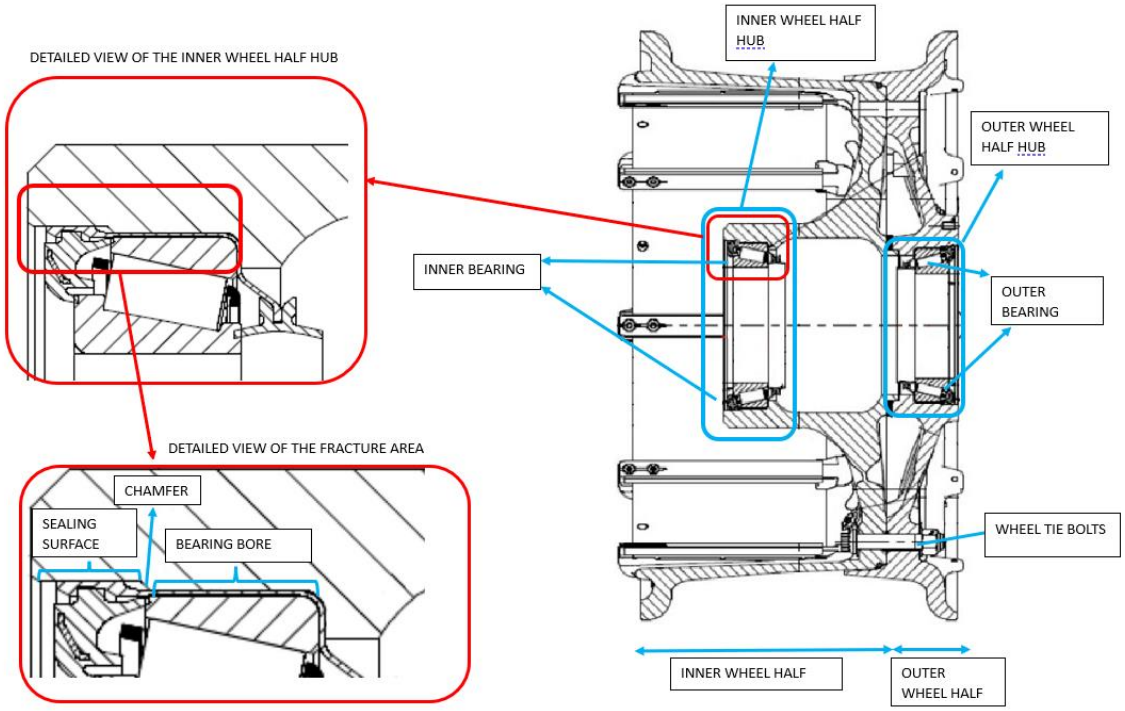

Figure 7 – Sketch of the wheel showing the area in which the fracture originated.

The wheel manufacturer provided the following information, with accompanying images, about its inspection and analysis of the fracture.

Figure 8 shows the hub fragments from the inner wheel half that were studied by the laboratory. Figure 9 shows a close-up of the largest fragment studied.

In both figures, the red arrows indicate the radial fractures, while the yellow arrows indicate the circumferential fractures. The green arrow indicates wear marks on the exterior of the hub.

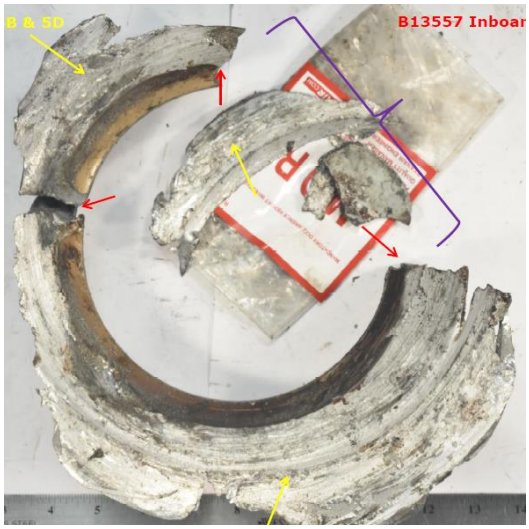

Figure 8 – Hub fragments from the inner wheel half studied by the laboratory.

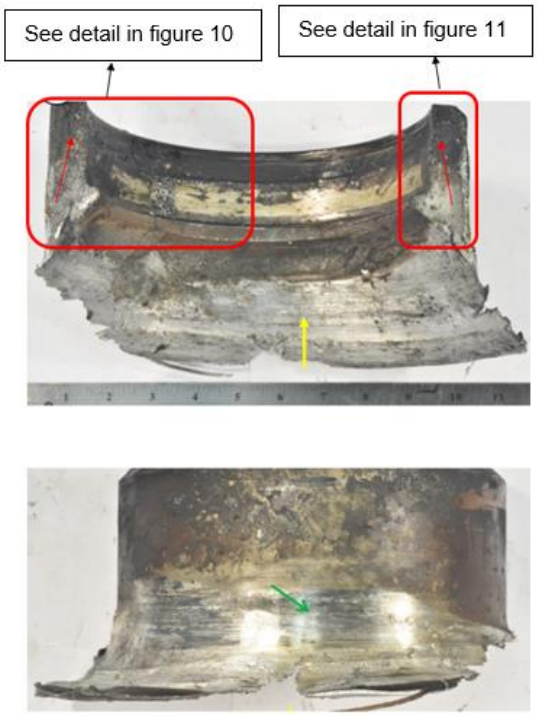

Figure 9 – Interior and exterior view of the largest of the inner wheel half hub fragments.

The following figures (figures 10 and 11) show close-up views of the two radial fracture surfaces on the largest hub fragment. Figure 10 also shows the other developing crack mentioned at the beginning of this section (detailed view in figure 12). In addition, figure 11 highlights, with a red bracket, the chamfer between the bearing bore and the sealing surface of the inner wheel half hub, which is where the fatigue crack that led to the fracture was found (detailed view in figure 13).

Figure 10 – Close-up of the inner wheel half hub fracture surface (1).

Figure 11 – Close-up of the inner wheel half hub fracture surface (2).

In the next figure (figure 12), image A shows the other crack identified (developing crack) by eddy current testing in another part of the hub of the inner wheel half. Laboratory work determined that this developing crack had the same origin and propagated in the same way as the crack that caused the primary fracture. Images C and D show the area where the corrosion was found and its approximate extent.

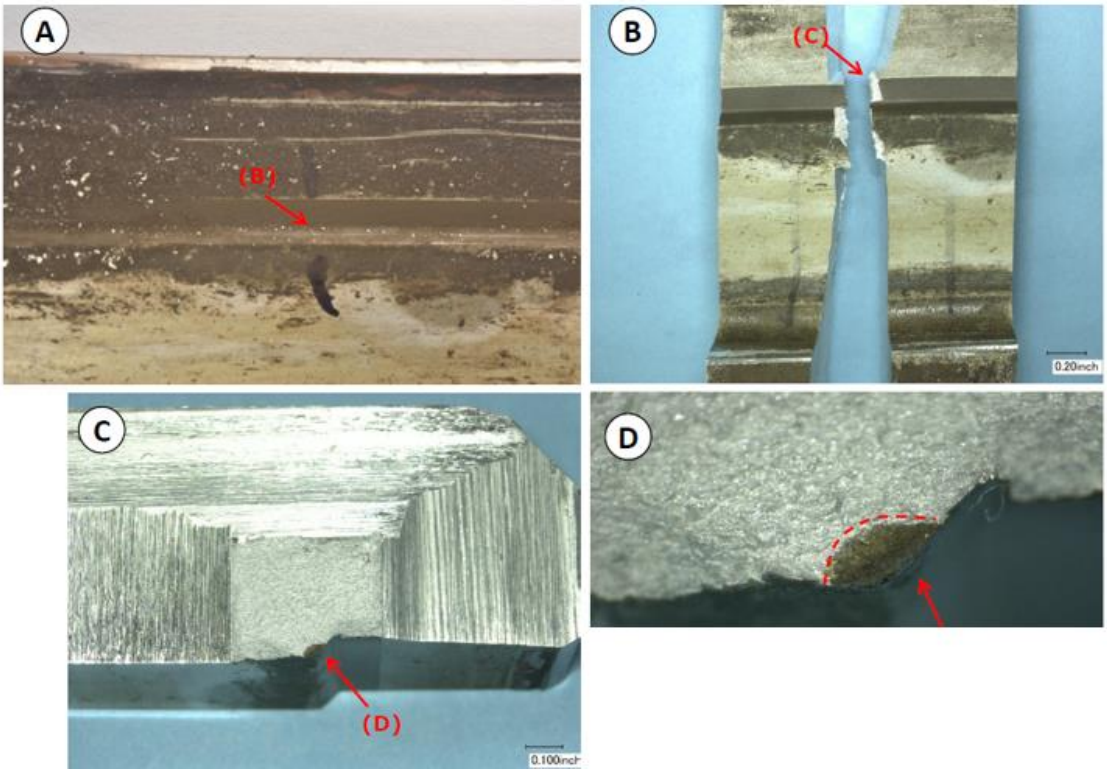

Figure 12 – Close-up of the other crack, with the same origin and characteristics as the crack that caused the primary fracture, in another section of the hub.

The figure below (figure 13) shows a close-up image of the fracture surface where the fatigue crack that led to the fracture was found. Typical fatigue fracture features were identified, originating around the chamfer between the inner bearing bore and the sealing surface. The dashed red line delineates the approximate extent of the area exposed to fatigue.

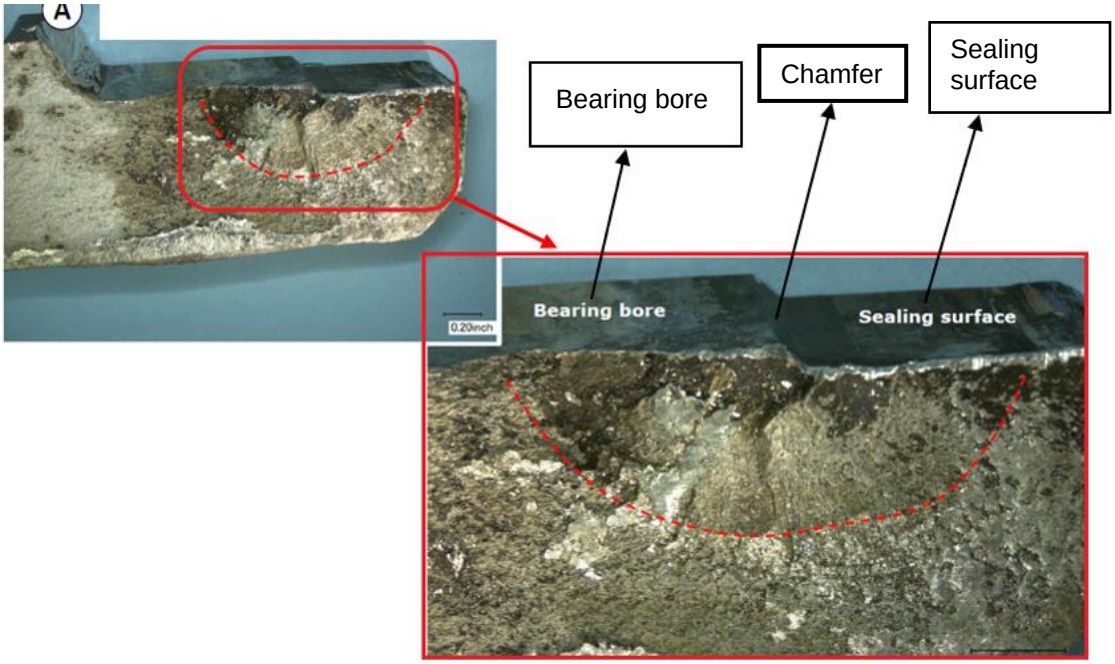

Figure 13 – Close-up of the fracture surface.

In addition to the macro-fractographic analysis of the fracture outlined above, a micro-fractographic study using scanning electron microscopy (SEM) was also carried out, confirming all of the findings described in this section.

Lastly, this study also confirmed that the material from which the wheel was made (aluminium 2014) had no signs of defects or anomalies.

1.17. Organisational and management information

Ryanair is a commercial carrier with an AOC issued by the Irish Aviation Authority (IAA). The AOC included the aircraft involved in the incident.

1.18. Additional information

Between August 2021 and March 2022, Ryanair experienced five similar incidents to this one, of which only one was subject to a formal investigation under ICAO Annex 13.

The investigated incident occurred on 17 March 2022 at Manchester Airport and involved a Boeing 737-8AS aircraft with registration EI-ENF, operated by Ryanair. The investigation was conducted by the AAIB[6].

The most relevant aspects of the report are set out below:

- Whilst taxiing through the airport after landing, the outboard wheel on the left main gear failed.

[6] https://assets.publishing.service.gov.uk/media/63905c79e90e071dfff6de05/Boeing_737-8AS_EI-ENF_01-23.pdf

- The analysis carried out by the operator's engineering department found that the hub of the inner wheel half of the left wheel on the left main landing gear had fractured.
- The wheel manufacturer's analysis of the fracture found that the inboard wheel hub had fractured radially in four locations. Three of these four radial fractures were all consistent with overload. The other fracture was associated with a fatigue crack originating at a corrosion pit located on the chamfer of the inner wheel hub.
- Following this incident that occurred on 17 March 2022 at Manchester Airport, the wheel manufacturer developed an ultrasonic inspection to locate cracks in the wheel hub, which the operator incorporated into its maintenance programme for the fleet of BOEING 737-8AS aircraft.

According to the information provided by the wheel manufacturer, the aforementioned ultrasonic inspection has been already incorporated in a new revision of the CMM (revision 13), to be carried out every second tyre change.

1.19. Special investigation techniques

N/A.

2. ANALYSIS

The following aspects were analysed during the investigation:

- The operation of the aircraft.
- The fracture of the wheel.
- The maintenance of the wheel.

2.1. The operation of the aircraft.

Based on the data provided in paragraph 1.11, it is considered that the parameters associated with the taxi and take-off at the departure airport and the landing at the destination airport were within normal operating parameters and that, therefore, the operation of the aircraft had no influence whatsoever on the incident.

During the taxi at the destination airport, a lack of consistency between the power applied to the engines and the taxiing speed can be identified, which is compatible with the fact that the left wheel on the left main landing gear was struggling to roll due to the fracture of its inner wheel half hub, which had occurred at some point after the aircraft had left the runway.

2.2. The fracture of the wheel.

As described under Heading 1, the left wheel on the aircraft's left main landing gear had fractured. Specifically, the fracture was found in the hub of the inner wheel half.

The wheel manufacturer's report found that the primary fracture was caused by a fatigue crack originating in one of the corners of the chamfer between the bearing bore and the sealing surface on the hub of the inner wheel half, and that there was corrosion in that area. This crack was hidden by the bearing cup.

As established by an AAIB report on a similar event (see section 1.18), it is considered that the crack that caused the primary fracture was caused by corrosion pits on the material's surface.

Thus, in this case, it is considered that the primary fracture had as a remote cause (the mechanism that initiated the failure procedure) the presence of corrosion pits on the internal surface of the hub and, as a direct cause, the creation and subsequent propagation of a fatigue crack that eventually caused sufficient damage to the material to result in the sudden fracture of the hub (overload fracture).

Therefore, it is considered that the failure process began with the creation of a fatigue crack in a corrosion pit (a weak point on the surface of the part where stresses are concentrated), which grew over time due to the varying nature of the loads to which the wheels are subjected. The crack continued to grow over time until it reached a critical size, at which point the hub ruptured suddenly due to overload when the wheel could no longer withstand the stresses to which it was subjected.

2.3. The maintenance of the wheel.

Firstly, according to Honeywell's CMM, the major overhaul must be performed every 24 months or 1800 cycles. Given that the fractured wheel had accumulated 229 hours and 148 cycles since the last assembly, which took place on 13-01-2022 after a major overhaul on 07-01-2022, the wheel was up to date with the required maintenance tasks.

Secondly, as specified in section 1.6, one of the tasks that form part of the wheel major overhaul (CMM revision 10, task code 32-40-14-000-025-A01) is designed to detect defects and anomalies in an area very close to the area where the fracture occurred. However, this particular task was not carried out during the major overhaul of the wheel just over two months before the incident. The reason for this was that the bearing cup was not removed from the wheel half because, as per the wheel manufacturer's instructions, unless the results of the standard visual inspections of the bearing cup and non-destructive testing inspections of the hub that must be performed during the overhaul require it, the bearing cup does not have to be removed from the hub during the major overhaul.

Thirdly, bearing in mind:

- The intervals specified for the major overhaul (24 months / 1800 cycles).
- The fact that fatigue failures are typically progressive, with the material suffering gradual damage during service over time, and therefore, this type of failure can generally be detected before the onset of catastrophic failure using the appropriate overhaul and maintenance techniques (e.g. non-destructive testing).
- The proximity of the area inspected by CMM revision 10 task code 32-40-14-000-025-A01 to the area of the break.

It is considered that the crack would most likely have been detected had the inspection task with code 32-40-14-000-025-A01 been carried out.

Therefore, the investigation finds that the instructions for the major overhaul of the wheel contained in CMM revision 10 (in force on the day of the incident) were not enough to ensure the integrity of the wheel during its service life. However, given that the wheel manufacturer initiated mitigating measures as a consequence of the incident mentioned in section 1.18 above, no safety recommendation will be issued in this respect. Details of these mitigation measures are included under Heading 4.

3. CONCLUSION

3.1. Findings

- The parameters obtained from the QAR for the aircraft's operation during the taxi to the runway and the take-off at the departure airport, as well as the landing at the destination airport, were within normal operating ranges.
- The wheel manufacturer's analysis of the fracture identified fatigue and corrosion on one of the fracture surfaces.
- The wheel manufacturer's analysis of the fracture identified a developing fatigue crack and corrosion on the hub of the inner wheel half. Laboratory work determined that this developing crack had the same origin and propagated in the same way as the crack that caused the primary fracture.
- The material from which the wheel was made (aluminium 2014) showed no signs of defects or anomalies.
- The inspection with CMM revision 10 task code 32-40-14-000-025-A01 was not performed during the last major overhaul.
- The wheel was up to date with the wheel manufacturer's prescribed maintenance.
- On 17 March 2022, another Boeing 737-8AS aircraft operated by Ryanair was involved in an incident caused by the same issue at Manchester Airport. The investigation carried out by the AAIB revealed the existence of a fatigue crack originating at a corrosion pit located on the chamfer of the hub of the inner wheel half.

3.2. Causes / Contributing factors

The investigation has concluded that the incident was caused by a fracture in the hub of the inner wheel half of the left wheel on the aircraft’s left main landing gear due to the propagation of a fatigue crack originating from a corrosion pit.

The fact that the instructions for the major overhaul of the wheel contained in CMM revision 10 (in force on the day of the incident) were not enough to ensure the integrity of the wheel during its service life is thought to have been a contributing factor.

4. SAFETY RECOMMENDATIONS

As indicated by the AAIB in its report (see section 1.18), the wheel manufacturer developed, as a mitigation measure, an ultrasonic inspection technique to locate cracks in the area of the wheel where the fracture occurred (the chamfer between the bearing bore and the sealing surface on the hub of the inner wheel half), which is also the area of the wheel affected by the fracture in the incident that is the subject of this investigation. The AAIB report also indicated that the operator had incorporated the ultrasonic inspection technique into its maintenance programme for the fleet of BOEING 737-8AS aircraft.

To expand on the above, during the investigation, further information was requested from the wheel manufacturer through the NTSB. According to the information provided, the wheel manufacturer has already incorporated the aforementioned ultrasonic inspection, to be carried out every second tyre change, in a new revision of the CMM (revision 13).

Consequently, considering the mitigation measure described above, no safety recommendations are deemed necessary.