



**COMISIÓN DE
INVESTIGACIÓN
DE ACCIDENTES
E INCIDENTES DE
AVIACIÓN CIVIL**

Report IN-033/2015

Incident involving an Airbus A-330-300,
registration EC-LZX, operated by Iberia,
and a Boeing B-777-200,
registration N758AN, operated by
American Airlines, at the Adolfo Suárez
Madrid-Barajas Airport (Spain)
on 6 December 2015



GOBIERNO
DE ESPAÑA

MINISTERIO
DE FOMENTO

Report

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COMISIÓN DE INVESTIGACIÓN DE ACCIDENTES E INCIDENTES DE AVIACIÓN CIVIL

Tel.: +34 91 597 89 63
Fax: +34 91 463 55 35

E-mail: ciaiac@fomento.es
<http://www.ciaiac.es>

C/ Fruela, 6
28011 Madrid (España)

Foreword

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

In accordance with the provisions in Article 5.4.1 of Annex 13 of the International Civil Aviation Convention; and with articles 5.5 of Regulation (UE) n° 996/2010, of the European Parliament and the Council, of 20 October 2010; Article 15 of Law 21/2003 on Air Safety and articles 1.4 and 21.2 of Regulation 389/1998, this investigation is exclusively of a technical nature, and its objective is the prevention of future civil aviation accidents and incidents by issuing, if necessary, safety recommendations to prevent from their reoccurrence. The investigation is not pointed to establish blame or liability whatsoever, and it's not prejudging the possible decision taken by the judicial authorities. Therefore, and according to above norms and regulations, the investigation was carried out using procedures not necessarily subject to the guarantees and rights usually used for the evidences in a judicial process.

Consequently, any use of this report for purposes other than that of preventing future accidents may lead to erroneous conclusions or interpretations.

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Abbreviations

° ' "	Sexagesimal degrees, minutes and seconds
°C	Degrees centigrade
AC	Advisory circular
ADI	Aerodrome Control Instrument rating
AESA	Spain's National Aviation Safety Agency
AGC	Airport ground chart
AIP	Aeronautical information publication
AIR	Air control endorsement
AIRAC	Aeronautical Information Regulation and Control
AIS	Aeronautical information service
AMDT	AIP amendment
ATPL (A)	Airline transport pilot license
ATC	Air traffic control
ATS	Air traffic service
CAT	Category
CAVOK	Ceiling and visibility OK
CS	Certification specifications
CS-ADR-DSN	Certification specifications and guidance material for aerodrome design
CVR	Cockpit voice recorder
DFDR	Digital flight data recorder
E	East
EC	European Community
EASA	European Aviation Safety Agency
ETOPs	Extended operations for twin-engine airplanes
EU	European Union
FAA	United States Federal Aviation Administration
FDM	Flight data monitoring
FDR	Flight data recorder
FOM	Development (Ministry)
ft	Feet
g	Acceleration due to gravity
GM	Guidance material
GMC	Ground movement endorsement
GMC	Ground movement control

GMS	Ground movement surveillance endorsement
h	Hours
hPa	Hectopascals
ICAO	International Civil Aviation Organization
IFR	Instrument flight rules
ILS	Instrument landing system
IR (A)	Instrument rating (airplane)
kg	Kilograms
km	Kilometers
kt	Feet
lb	Pounds
LCL	Local
LEMD	ICAO code for the Adolfo Suárez Madrid-Barajas Airport
m	Meters
METAR	Routine aviation weather report
MHz	Megahertz
MLS	Microwave landing system
N1	Rotation speed of the low-pressure group (compressor and turbine)
N/A	Not affected / not available
P/N	Part number
PTT	Push to talk (radio)
QNH	Altimeter subscale setting to obtain elevation when on the ground
R.D.	Royal Decree
RAD	Aerodrome radar control endorsement
RCA	Air Traffic Regulation
RH	Right Hand
RVR	Runway visual range
s	Seconds
SDP	Apron management service
SMS	Safety management system
RFFS	Rescue and firefighting service
TWR	Control tower endorsement
TWY	Taxiway
UTC	Coordinated universal time

Synopsis

Operator:	IBERIA	AMERICAN AIRLINES
Aircraft:	Airbus A-330, EC-LZX	Boeing B-777, N758AN
Date and time of incident:	Sunday, 6 December 2015 at 12:58 UTC	
Site of incident:	Adolfo Suárez Madrid-Barajas Airport (Spain)	
Personas a bordo:	220 passengers, 12 crew	173 passengers, 12 crew
Tipo de vuelo:	Air transport – Scheduled – – International – Passenger	Air transport – Scheduled – – International - Passenger
Phase of flight:	Taxi	
Date of approval:	26 April 2017	

Summary of event:

A Boeing B-777 aircraft, registration N758AN, operated by American Airlines, was preparing to carry out flight AAL037 to the Dallas-Fort Worth Airport (United States). It was stopped on taxiway Z1, awaiting clearance to enter runway 36L.

An Airbus A-330-300, registration EC-LZX, operated by Iberia, had landed on runway 32L inbound from the Miami Airport (United States) on flight IBE6118. Its crew had been instructed to taxi on standard route B to gate 12. As it reached the intersection of taxiways B2, B3 and Z1, the left wing on the A-330 struck the right elevator on the B-777, registration N758AN, which was stopped at Z1, causing a crack on the lower surface. The A-330 continued taxiing, which resulted in its left winglet impacting the right wingtip on the B-777.

The investigation has determined that this incident occurred due to the decision of the crew of aircraft EC-LZX to continue taxiing behind aircraft N758AN even though its crew were aware that this aircraft was very close to the taxiway they were taxiing on.

The following factors contributed to this incident:

- Aircraft N758AN had stopped 40 m away from the holding point sign for runway 36L, such that it was encroaching on the strip of taxiway B.
- The failure by Jeppesen to include in its airport information a note from the aerodrome map for ground movements (ICAO) published in the AIP Spain stating that “aircraft shall taxi as close as possible to runway and intermediate holding points...”

1. FACTUAL INFORMATION

1.1. History of the flight

The Boeing B-777 aircraft, registration N758AN, operated by American Airlines, was preparing to carry out flight AAL037 to the Dallas-Fort Worth Airport (United States). It had been cleared to taxi from parking stand 580 to taxiway Z1, which connects to runway 36L. After reaching taxiway Z1, the crew stopped taxiing and awaited clearance to enter the runway.

The Airbus A-330-300, registration EC-LZX, operated by Iberia, had landed on runway 32L inbound from the Miami Airport (United States) on flight IBE6118. Its crew had been instructed to taxi on standard route B to gate 12. As it reached the intersection of taxiways B2, B3 and Z1, the left wing on the A-330 struck the right elevator on the B-777, registration N758AN, which was stopped at Z1, causing a crack on its lower surface. The A-330 continued taxiing and moments later a second impact took place, as the left winglet on the A-330 struck the trailing edge of the right wing on the B-777. The winglet penetrated about halfway into the wing until it broke off, with the detached winglet component becoming embedded in the wing of the B-777.



Figure 1. Diagram of the aircraft positions at the time of the impact

The A330 continued taxiing to its assigned stand. The crew of the B-777 requested assistance from the airport's firefighting service to evaluate the damage to the aircraft. It was concluded that it was safe for the aircraft to move under its own

power, and thus the aircraft taxied to the parking apron, where the passengers were disembarked.



Figure 2. Right wingtip of the B777 with part of the embedded A330 winglet

1.2. Injuries to persons

1.2.1. Aircraft EC-LZX

Injuries	Crew	Passengers	Total in the aircraft	Other
Fatal				
Serious				
Minor				N/A
None	12	220	232	N/A
TOTAL	12	220	232	

1.2.2. Aircraft N758AN

Injuries	Crew	Passengers	Total in the aircraft	Other
Fatal				
Serious				
Minor				N/A
None	12	173	185	N/A
TOTAL	12	173	185	

1.3. Damage to aircraft

1.3.1. Aircraft EC-LZX

The aircraft's left winglet was broken by the impact against the right elevator and wing of aircraft N758AN.

When the winglet was removed from the left wing, it was noted that the wing's support structure had sustained minor damage which required repairs.



Figure 3. Photograph of the cut in the right elevator of aircraft N758AN (left) and of the left wingtip of aircraft EC-LZX (right)

1.3.2. Aircraft N758AN

The B777 aircraft, registration N758AN, sustained minor damage to its horizontal stabilizer and right elevator, as well as to its right wing.

1.4. Other damage

There was no other damage.

1.5. Personnel information

1.5.1. Aircraft EC-LZX

1.5.1.1. Captain

- Age: 61
- Nationality: Spanish
- License: ATPL (airplane)
- Ratings:
 - A330 valid until 31/12/2015
 - A340 valid until 20/06/2016
- IR (A) valid until 20/06/2016
- Medical certificate: class 1, valid until 15/03/2016
- Total flight hours: 17100
- Flight hours on the aircraft type: 909
- Flight activity:
 - Previous 90 days: 198:59 h
 - Previous 7 days: 18:07 h
 - Previous 24 h: 08:21 h
 - Rest prior to flight: 29:04 h

1.5.1.2. First officer

- Age: 44
- Nationality: Spanish
- License: ATPL (airplane)
- Ratings:
 - A330 valid until 31/03/2016
 - A330/350 valid until 30/09/2016
- IR (A) valid until 30/09/2016
- Medical certificate: class 1, valid until 1/03/2016

- Total flight hours: 5467
- Flight hours on the aircraft type: 175
- Flight activity:
 - Previous 90 days: 147:37 h
 - Previous 7 days: 25:28 h
 - Previous 24 h: 08:21 h
 - Rest prior to flight: 29:04 h

1.5.1.3. Pilot under instruction

- Age: 51
- Nationality: Spanish
- License: ATPL (airplane)
- Ratings:
 - A320 valid until 31/05/2016
 - A330/350 valid until 31/10/2016
- IR (A) valid until 31/10/2016
- Medical certificate: class 1, valid until 30/03/2016
- Total flight hours: 9065
- Flight hours on the aircraft type: 90
- Flight activity:
 - Previous 90 days: 100:09 h
 - Previous 7 days: 26:45 h
 - Previous 24 h: 08:21 h
 - Rest prior to flight: 29:04 h

1.5.2. Aircraft N758AN

1.5.2.1. Captain

- Age: 60
- Nationality: American
- License: ATPL (airplane)

- Ratings:
 - B-727
 - B-757
 - B-767
 - B-777
 - DC-9
- Medical certificate: class 1, valid until 12/02/2016
- Total flight hours: 17510
- Flight hours on the aircraft type: 422
- Flight activity:
 - Previous 90 days: 142:54 h
 - Previous 7 days: 8:49 h
 - Previous 24 h: 0:00 h
 - Rest prior to flight: 25:09 h

1.5.2.2. First officer

- Age: 52
- Nationality: American
- License: ATPL (airplane)
- Ratings:
 - B-757
 - B-767
 - B-777
 - CE-500
 - MD-11
- Medical certificate: class 1, valid until 11/02/2016
- Total flight hours: 10744
- Flight hours on the aircraft type: 3178
- Flight activity:
 - Previous 90 days: 130:17 h

Previous 7 days: 8:49 h

Previous 24 h: 0:00 h

Rest prior to flight: 25:09 h

1.5.2.3. Relief pilot

- Age: 58
- Nationality: American
- License: ATPL (airplane)
- Ratings:
 - B777
- Medical certificate: class 1, valid until 25/08/2016
- Total flight hours: 7415
- Flight hours on the aircraft type: 3000
- Flight activity:

Previous 90 days: 204:07 h

Previous 7 days: 34:01 h

Previous 24 h: 0:00 h

Rest prior to flight: 25:09 h

1.5.3. Aerodrome control service

1.5.3.1. Controller at position GMC CENTRAL-NORTH

The controller, a Spanish national, had an air traffic controller license initially issued by Spain's National Aviation Safety Agency (AESA) on 31/08/2004, and a medical certificate valid until 14/12/2015. He also had the following unit endorsements: ADI/AIR-RAD, ADI/GMC-GMS and ADI/TWR-GMS-RAD, valid until 2 October 2016.

1.5.3.2. Controller at position LCL 36L

The controller, a Spanish national, had an air traffic controller license initially issued by Spain's National Aviation Safety Agency (AESA) on 25/01/2005, and a medical certificate valid until 19/06/2016. He also had the following unit endorsements: ADI/TWR/GMS/RAD, valid until 6 January 2017.

1.6. Aircraft information

1.6.1. Aircraft EC-LZX

- Manufacturer: Airbus
- Model: A330-302
- Serial number: 1507
- Year of manufacture: 2014
- Engines, number, manufacturer and model: two (2)/General Electric/CF6-80E1A4B
- Weights
 - o Maximum takeoff weight: 235,000 kg
 - o Empty weight: 130,988 kg
- Dimensions
 - o Wingspan: 60.30 m
 - o Length: 63.69 m
 - o Height: 16.83 m
 - o Wheelbase: 10.69 m
- Hours: 8922
- Cycles: 1116
- Certificate of airworthiness: issued on 19/03/2014 by AESA.
- Airworthiness review certificate: valid until 18/02/2016.
- Maintenance status:

Last inspections of aircraft			
<i>Type of inspection</i>	<i>Total hours</i>	<i>Total cycles</i>	<i>Date</i>
C1-check	7566	935	7/09/2015
B1-check	8179	1018	21/10/2015
H1+A4-check	8578	1067	18/11/2015

1.6.2. Aircraft A758AN

- Manufacturer: Boeing

- Model: B777-223
- Serial number: 32637
- Year of manufacture: 2001
- Engines, number, manufacturer and model: two (2)/Rolls-Royce RB211 Trent 892-17
- Weights
 - o Maximum takeoff weight: 247,210 kg (535,000 lb)
 - o Empty weight: 139,025 kg (306,500 lb)
- Dimensions
 - o Wingspan: 60.90 m
 - o Length: 63.70 m
 - o Height: 18.50 m
 - o Wheelbase: 11.00 m
- Hours: 58359.49
- Cycles: 7302
- Certificate of airworthiness: issued on 6/11/2001 by the FAA.
- Airworthiness review certificate: valid until 18/02/2016.
- Maintenance status:

Last inspections of aircraft			
<i>Type of inspection</i>	<i>Total hours</i>	<i>Total cycles</i>	<i>Date</i>
ETOP's check	58341	7300	5/12/2015

1.7. Meteorological information

The METAR's for the Adolfo Suárez Madrid-Barajas Airport issued between 11:00 and 13:30 UTC on the day of the event were as follows:

METAR LEMD 061100Z 33003KT 260V020 CAVOK 11/04 Q1030 NOSIG=

METAR LEMD 061130Z 34003KT 270V020 CAVOK 13/05 Q1030 NOSIG=

METAR LEMD 061200Z 33004KT 280V030 CAVOK 14/05 Q1029 NOSIG=

METAR LEMD 061230Z 33003KT 230V040 CAVOK 15/05 Q1029 NOSIG=

METAR LEMD 061300Z 26002KT CAVOK 15/04 Q1029 NOSIG=

METAR LEMD 061330Z 21002KT CAVOK 16/04 Q1028 NOSIG=

The 12:00 UTC METAR, which was closest to the time of the event, indicates that in the ten previous minutes, the average wind direction and speed had been 330° and 4 kt.

During this same time period, the wind direction varied between 280° and 30°.

The sky was clear and visibility was in excess of 10 km. The temperature was 14° C, the dewpoint 5° C and the QNH 1029 hPa. No significant changes were expected.

1.8. Aids to navigation

Not applicable.

1.9. Communications

1.9.1. Aircraft EC-LZX

Aircraft EC-LZX established contact with GMC – Central-North on a frequency of 125,150 MHz at 11:56:25 UTC to report that they had exited the runway via L2.

The controller informed the crew that taxiway B was clear and instructed them to proceed on B, short of gate 12 and to change to 121,625 MHz (GMC E-SOUTH) for further instructions, which the crew acknowledged.

At 11:57:06, the GMC E-SOUTH controller contacted the crew on 121,625 MHz to instruct them to proceed via gate 12 to parking stand 515, which the crew acknowledged.

At 11:59:40, the GMC E-South controller again called the crew to inform them that they had struck the aircraft located at Z1.

1.9.2. Aircraft N758AN

At 11:48:13, the GMC E-NORTH controller called the crew of aircraft N758AN to inform them they were cleared to push back, facing south, which the crew acknowledged.

The controller added to taxi on taxiway A after pushing back.

At 11:51:14, the crew called the controller to report they had started taxiing.

The controller instructed them to taxi and take the second right (which is taxiway A), and to hold at A20. The crew correctly acknowledged the instruction.

At 11:59:02, the controller transferred the crew to GMC CENTRAL-NORTH (123,150 MHz).

The crew called the GMC CENTRAL-NORTH controller 20 seconds later to report they were on taxiway A.

The controller instructed them to continue taxiing on A, B and to hold short of B1 and that he would call later with further instructions.

The crew acknowledged "OK", A and B7 as the limit.

The controller responded "negative" and repeated the instruction that they wait at A22, short of B1.

The crew acknowledged A and B22.

At 11:53:12, the controller again called the crew to inform them that when they were clear of an EasyJet that was going to cross from the left to right that was now taxiing on taxiway M, to continue on B and Z1 to the runway 36L holding point, behind.

The crew acknowledged that ... behind the EasyJet that we see on B2, to runway 36L.

At 11:54:51, the controller called the crew to instruct them to turn left on Z1, and transferred them to the control tower (LCL 36L) on 118,075 MHz. The crew acknowledged: now left on Z1 and 118.750.

The controller repeated the frequency, 118.075, which was correctly acknowledged. This final communication with GMC CENTRAL-NORTH took place at 11:55:07.

At 11:58:02, the crew of N758AN called LCL 36L (118,075 MHz) to report that they thought they had been struck by an Iberia aircraft and that they thought it necessary for that aircraft to stop.

1.10. Aerodrome information

1.10.1. Certification status

On the date of the incident, the Adolfo Suárez Madrid-Barajas Airport was certified by Spain's National Aviation Safety Agency (AESA). The initial certification had been issued on 14/04/2011 and was valid until 31/12/2015.

The certification regulation in effect at the time was Royal Decree 862/2009 of 14 May, which approved the technical regulations for the design and operation of public-use aerodromes and regulated the certification of aerodromes under the government's oversight.

The taxiways in the area of the incident, specifically taxiways Z1, Z3 and B, are certified for operations by type-F aircraft.

On 14 February 2014, Commission Regulation (EU) no. 139/2014 of 12 February 2014 was published in the Official Journal of the European Union, laying down requirements and administrative procedures related to aerodromes pursuant to Regulation (EC) no. 216/2008 of the European Parliament and of the Council.

This regulation constitutes the common regulation for certifying airports and replaces the national regulations of the member States.

As specified in Article 6 of this regulation, the certificates issued by the competent authority prior to 31 December 2014 pursuant to national law shall remain valid until they are issued pursuant to said article or, if said certificates have not been issued, until 31 December 2017.

To expand this regulation, the European Aviation Safety Agency (EASA) has drafted and published certification specifications (CS) and guidance material (GM) for aerodrome design (CS-ADR-DSN).

1.10.2. Technical regulation on the design of aerodromes. Taxiways

The regulations and recommendations for designing taxiways are contained in Royal Decree 862/2009 of 14 May, referenced in the previous point.

Each taxiway must be located within a strip that has to extend a minimum distance to either side of the taxiway, depending on the aerodrome's reference code.

The strip is an obstacle-free zone whose main purpose is to ensure adequate separation between the aircraft moving on that taxiway and any object, as well as with other aircraft located on other taxiways or on the runway.

Taxiways Z1 and Z3 are code F, although the airport as a whole has reference code 4-E. The minimum width that the strip must extend to either side of the taxiway centerline is 47.5 m for code letter E and 57.5 m for code letter F, pursuant to Royal Decree 862/2009.

The certification specifications for aerodrome design (CS-ADR-DSN) issued by the EASA specify smaller dimensions for runway strips, whose values are 43.5 m for code letter E and 51.0 m for code letter F.

Figure 4 contains an aerial photograph of the 36L threshold area, which shows the length between the edge and the middle of the strip for taxiways Z1 and Z3 for the purpose of seeing if there is any interference or overlap.

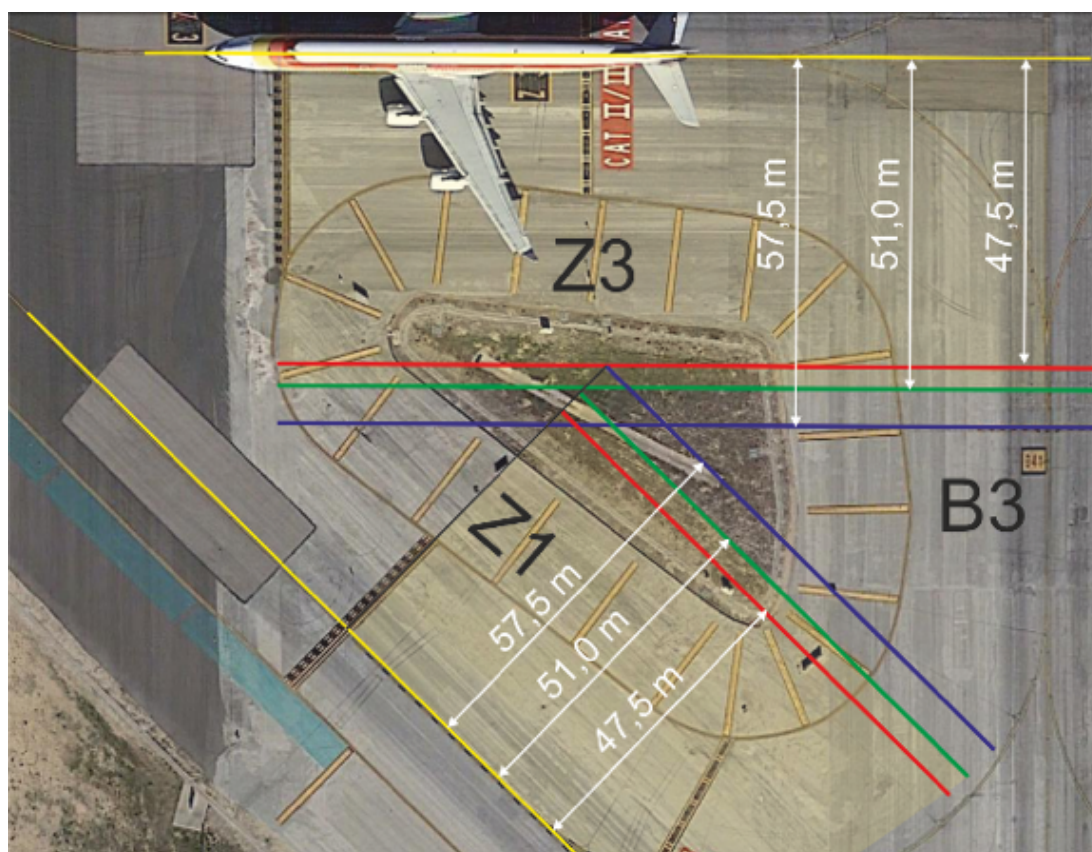


Figure 4. Photograph of taxiways Z1 and Z3, showing the distance from the edge to the centerline associated with codes E (as per RD 862/2009) and F (as per RD 862/2009 and CS-ADR-DSN)

1.10.3. Regulation on airport markings in Spain

The technical regulations for the design and operation of public-use airports, as well as the regulation for the certification of airports under government oversight, are contained in Royal Decree 862/2009 of 14 May.

The annex to this Royal Decree, which contains the technical regulations, is based, with the necessary adaptations, on ICAO (International Civil Aviation Regulation) Annex 14. This Annex was updated via Development Ministry Order 2086/2011 of 8 July to incorporate amendment 10, A and B to Volume I of Annex 14, as well as amendment 4 to Volume II of this same annex, which had been adopted by the ICAO Council after the publication of the Royal Decree.

Point 5.2.10 of the annex to the Royal Decree involves markings at holding points. Point 5.2.10.3 specifies that: when a single runway holding point is present at the intersection of a taxiway with a runway with a Category I, II or III precision approach, the marking at the holding point shall be of the form shown in Figure 5-8 (in that document, see Figure 5 in this report), configuration A. When the two or three runway holding points are present at the intersection of a taxiway with a runway with a Category I, II or III precision approach, the marking for the holding point closest to the runway shall be of the form shown in Figure 5-8, configuration A, and the marking furthest from the runway shall be of the form shown in Figure 5-8, configuration B.

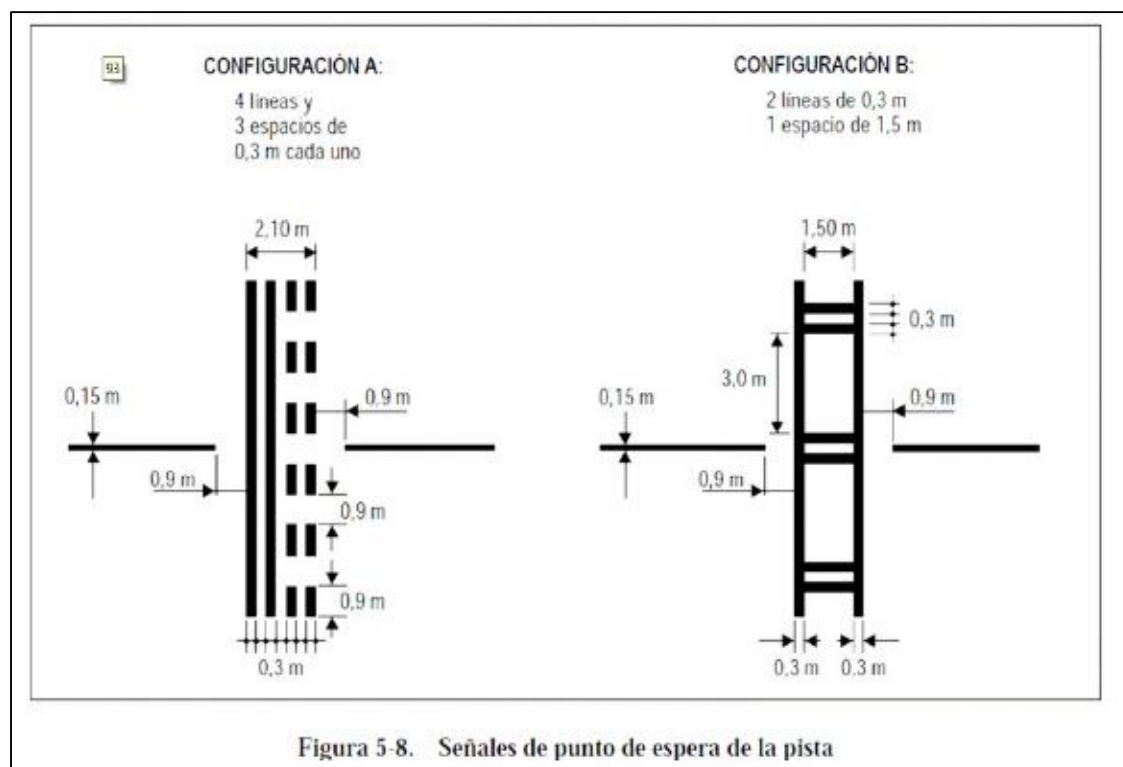


Figure 5. Reproduction of Figure 5-8 in the Annex to Royal Decree 862/2009

The features of these markings are defined in Figure 5-8, shown below.

The regulation in effect at the time of the event was the national one. As a result of the publication of regulation (EU) No. 139/2014, the applicable technical regulation for the design of airports is the one contained in the EASA's CS-ADR-DSN. The specifications for the marking of holding points are specified in point CS ADR-DSN.L.575 in that document. The characteristics for these markings as contained in said point are identical to those in Royal Decree 862/2009.

1.10.4. International regulation on airport markings

These markings are regulated by point 5.2.10 (same numbering as in the RD) of ICAO Annex 14, whose contents are practically the same as in the Royal Decree.

1.10.5. Regulation on airport markings in the United States

These markings are regulated by AC 150/5340-IL, "Standards for airport markings", the last update to which was published on 27 September 2013.

Chapter 3 is on "Holding position markings" and considers two different types of markings, which are identical to those described in point 1.10.4 above. They are applicable in six different operational scenarios.

The marking in pattern A, at a taxiway that intersects a runway, is used to identify the point where the pilot, or the driver of a vehicle, must stop until cleared by ATC to enter the runway.

The marking in pattern B at a taxiway identifies the place where a pilot, or the driver of a vehicle, must stop after receiving instructions from ATC to hold before entering the critical area of an ILS or MLS.

As concerns the location of this marking, it indicates that when the distance between a pattern-A runway holding point marking located on a taxiway, and a pattern-B ILS/MLS holding point marking is less than 50 ft (15 m), a single holding point shall be established. In this case, the runway holding point (pattern A) shall be moved back to the position of the ILS/MLS holding point, and only a pattern-A marking shall be painted.

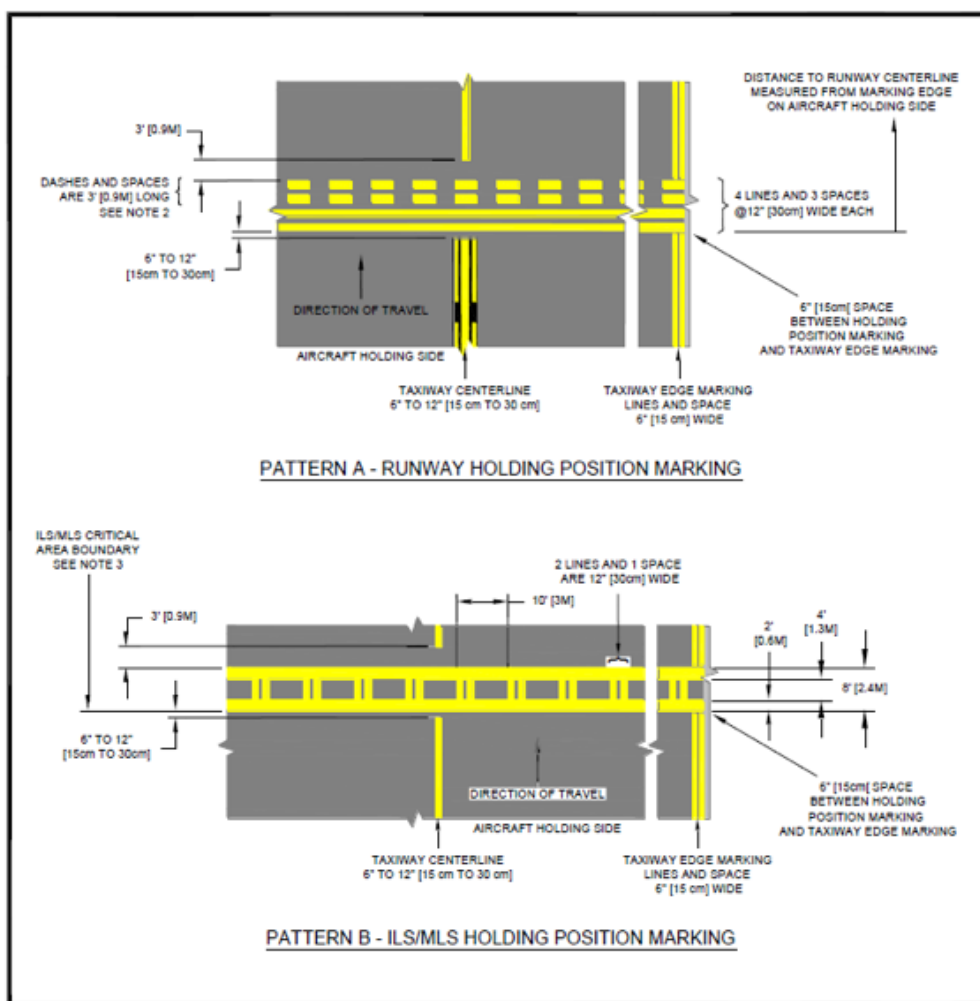


Figure 6. Reproduction of Figure A-13, "Holding position marking details", in AC 150/5340-IL, "Standards for airport markings"

1.10.6. Configuration of incident area. Information published in the AIP-Spain

The incident occurred in an area close to the runway 36L threshold at the Adolfo Suárez Madrid-Barajas Airport (LEMD).

In this area there are two taxiways, identified as Z1 and Z3, which connect taxiway B (B1, B2, B3, ... B13), which runs parallel to runway 18R-36L, to the runway 36L threshold. The first of them, Z1, is at an angle of 45° to the runway, while Z3 is perpendicular to the runway.

Taxiways Z1 and Z3 are 25 meters wide, while B2 and B3 are 45 m wide.

Aircraft N758AN was stopped on taxiway Z1, and aircraft EC-LZX was taxiing on taxiway B (B2 and B3).

The one closest to the runway corresponds to configuration A, described in the same point as in the paragraph above.



Figure 9. Photograph of taxiways Z1 and Z3, taken from the GMC-EN post in the control tower

This chart also contains a note, in Spanish only, with the following text: “aircraft shall taxi as close as possible to runway and intermediate holding points, since clearance behind said points is not guaranteed (see AD 1.1). It is an aircraft captain’s responsibility to watch their surroundings and take measures to avoid collisions with other aircraft and to inform ATC when they cannot comply with a requirement”.

Figure 8 shows a portion of point 11 of AD 1.1 in the AIP Spain concerning runway and intermediate holding points. This information is not specific to the Adolfo Suárez Madrid-Barajas Airport; rather, it is applicable in general to all Spanish airports.

As Figure 7 shows, the control tower is located between the T-4S satellite terminal building and runway 18R-36L, very close to the site of the incident.

Figure 9 shows a photograph of the incident site, taken from the GMC-EN post in the control tower. Labeled on the figure are taxiways Z1 and Z3, as well as the CAT I and CAT II/III holding points on taxiway Z1.

Figure 10 shows a diagram of the location of the control stations in the tower. The position of the GMC-EN position is shown inside the red arrow, the tip of which points in the same direction from which the photograph in Figure 9 was taken.

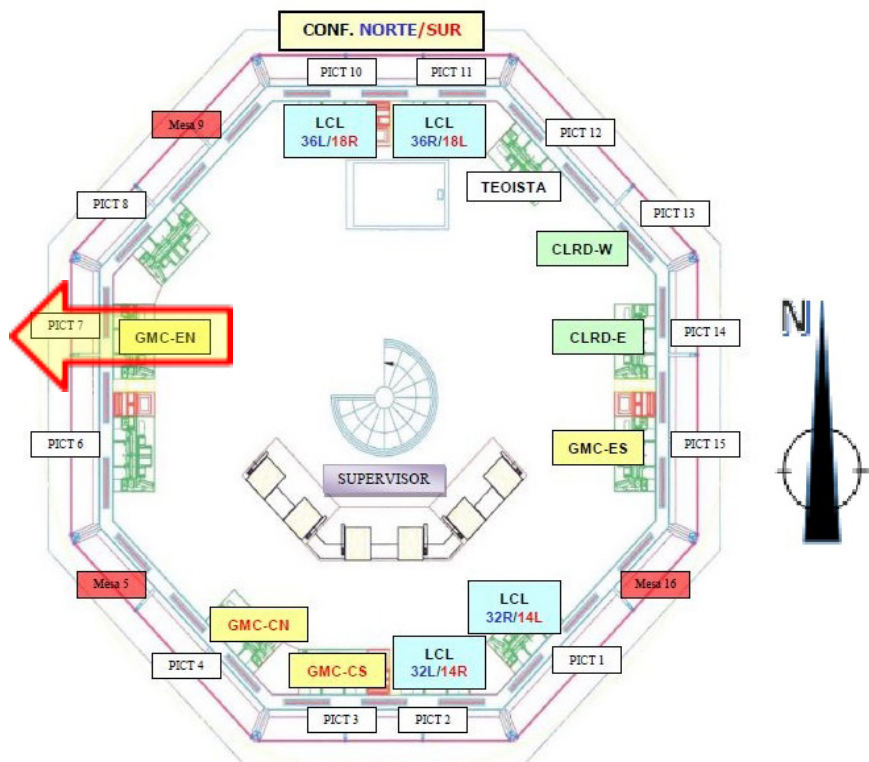


Figure 10. Location of control stations in the tower

1.10.7. Taxi procedures

These are contained in Section 20, "Local regulations", on the airport's file in AD 1.1 of the AIP Spain.

The aircraft with callsign IBE6118 landed on runway 32L and was assigned parking stand 515, which is on ramp 23 (Terminal 4 – Satellite). The standard taxi route from runway 32L to stand 515 would be: L4, L42, L2, B1 or L2, B1 and take B2, ... B5, gate 13, EA5.

The aircraft with callsign AAL037 had been parked at stand 580 and had been cleared to taxi to the runway 36L holding point on taxiway Z1.

The standard taxi route would be: EB2, EB6, EB7, N10, N9, N6, ..., N4, N3, G11, Z1. This was different from the one provided to the crew of AAL037.

As specified in the procedures, aircraft are to taxi by following the appropriate standard taxi route unless GMC or the Apron Management Service (SDP) specify a different route.

1.10.8. Instructions for aircraft operations

The Adolfo Suárez Madrid-Barajas Airport has specific operating instructions intended to lay out concrete procedures for dealing with non-standard scenarios.

For example, instruction IO-33-GOPS.01 specifies the measures to take in stands and taxi routes to ensure the safe operation of B747-8F type aircraft to/from the parking stand and from/to the runway in use, and listing the conditions specific to the apron in which they can operate: T123.

Among the measures included in this instruction is a restriction that affects the holding points on Z1 and Z3, namely that no aircraft may remain at said holding points when a type-F aircraft is taxiing in the vicinity.

1.11. Flight recorders

1.11.1. Aircraft EC-LZX

The flight recorders were synchronized using the communications held with ATC stations, the audio from which is recorded on the CVR. The FDR records the time when a crewmember presses the PTT (push to talk) button to talk on the radio.

1.11.1.1. Flight data recorders

The aircraft was equipped with a Honeywell HFR5-D flight data recorder, serial number FDR-02597.

The recorder was downloaded at Iberia's facilities and verified to contain valid information from the incident flight.

According to the information recorded, the aircraft landed at 11:55:22 UTC.

At 11:56:04, it started to turn right to exit the runway via rapid exit taxiway L-2.

The graph in Figure 11 shows the captain's inputs to the brake pedal, as well as the trend in the aircraft's speed, from 11:56:39 until 11:58:11, which was 12 seconds after the collision.

As the graph shows, the pilot reduced the aircraft's speed as it approached taxiway Z1. In fact, 6 s before the two aircraft came into contact, the aircraft's taxi speed had been reduced to 5 kt.

The graph also shows that about 25 s before the impact, the captain turned the wheel to the right (plus sign in the graph), keeping it turned to that side until 11:57:37, when he returned it to its neutral position.

It remained in that position for 4 s, and at 11:57:51 it was turned slightly to the left, where it remained until 11:57:58.

At 11:57:51, a slight increase in lateral acceleration was recorded, reaching a maximum value of 0.043 g.

At 11:57:59, another increase in lateral acceleration was recorded, peaking at 0.145 g.

The brake pedals were not activated at any time during the period from 11:57:54 and 11:58:31.

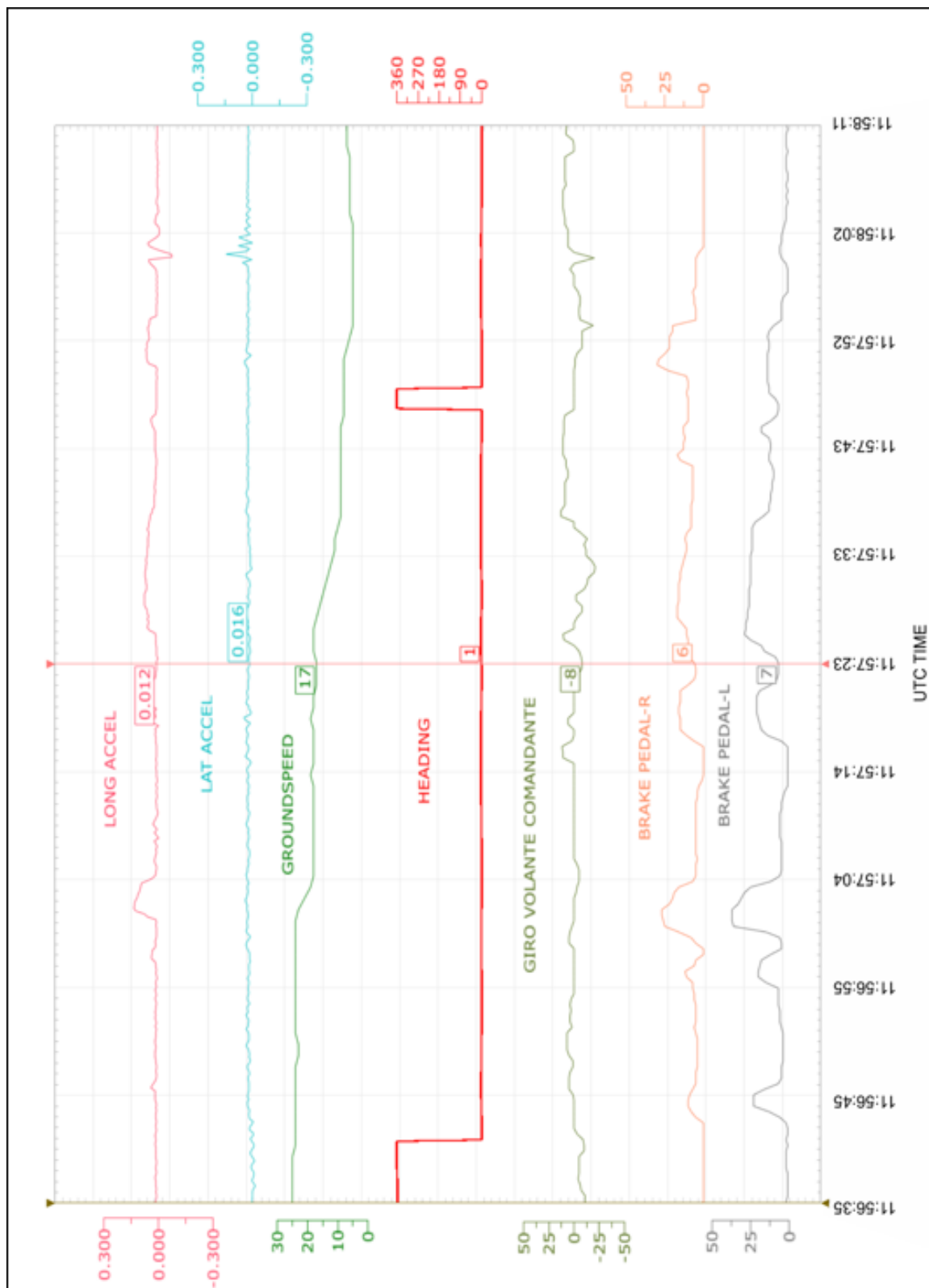


Figure 11. Graph with several parameters from aircraft EC-LZX

1.11.1.2. Cockpit voice recorder

The aircraft was equipped with a Honeywell HFR5-V cockpit voice recorder, serial number CVR-02371.

The recorder was downloaded at Iberia's facilities, where all four channels were verified to contain audible information, of high quality on channels 1, 2 and 3, and of medium to low quality on channel 4.

The recordings were reviewed from the time the crew informed ATC they were clearing the runway via L2 (11:56:07 UTC) until the event. All of the communications were standard, with the following being of most relevance to the event:

At 11:57:27, the captain is heard saying, "They're a little...", with the first officer adding the word "misaligned".

The first officer then asked, "Should I ask if he can move forward or what?", to which the captain replied, "No, no, we can make it".

At 11:58:01, the first officer said, "Uh, what happened?"

Figure 12 shows the position of the aircraft at different times as it was taxiing on runway B. For each time, the table shows the degree of deflection for each brake pedal, the aircraft's speed and the conversations in the cockpit.

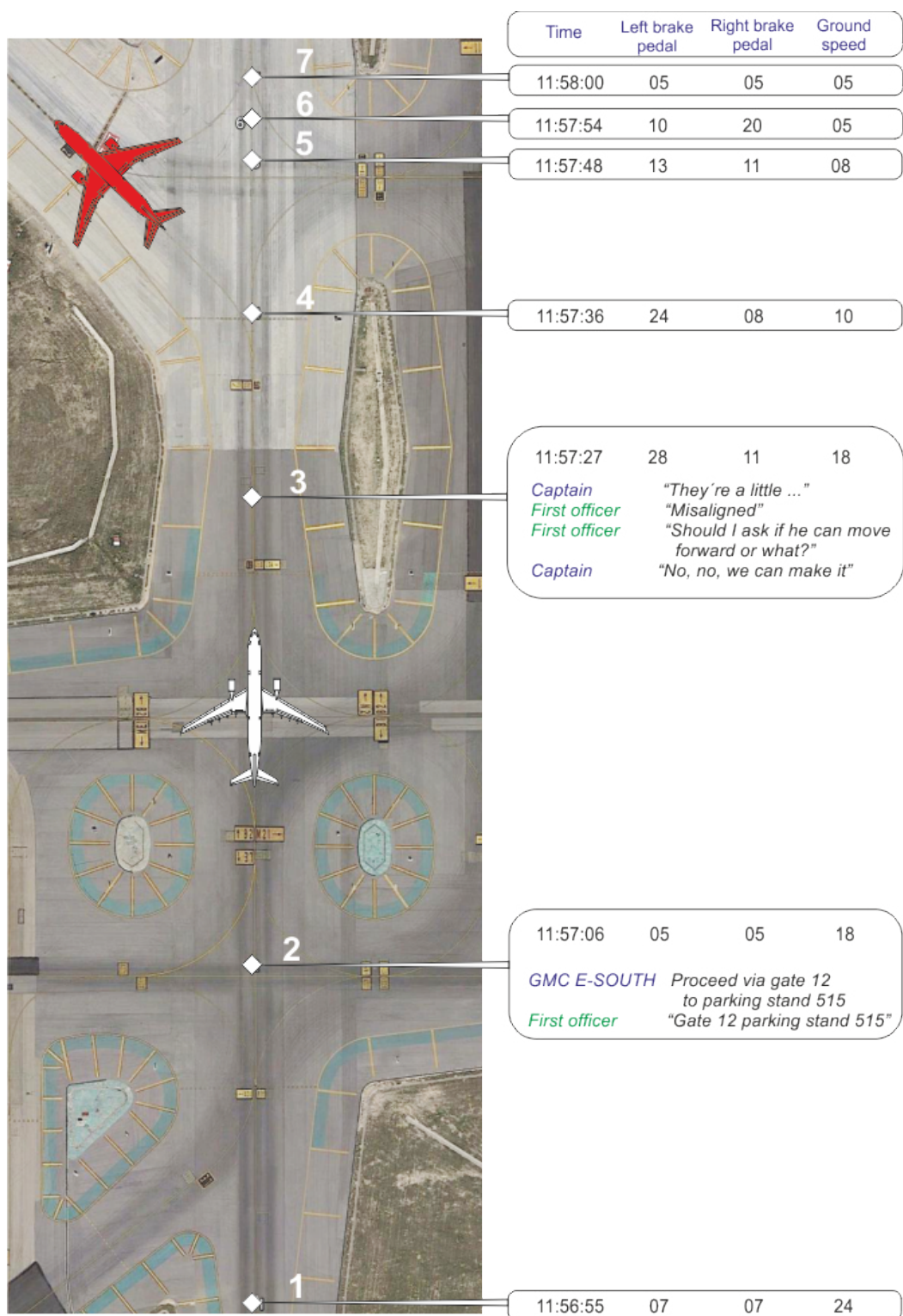


Figure 12. Detail from taxi phase of aircraft EC-LZX on taxiway B

1.11.2. Aircraft N758AN

1.11.2.1. Flight data recorder

The aircraft was equipped with a Fairchild 2100 flight data recorder, P/N 2100-4043-00 and serial number 00682.

The data recorder started recording at 11:49:51 UTC, when the start-up procedure for the first engine was commenced. At that moment, the aircraft was completing its tractor pushback procedure from stand 580 and was already facing south.

Figure 13 shows a graph with the trend for several parameters: ground speed, longitudinal and lateral accelerations, heading, parking brake, brake pressure (left and right) and engine speed (N1), spanning from 11:50:59 until 11:58:31 UTC.

At 11:51:02, the crew released the parking brake. The engines started to spool up 27 s later, and the aircraft began taxiing at 11:51:32.

It moved on a heading of 180 until it started to turn right to heading 270 at 11:52:22.

These data are fully consistent with the taxi route taken by the aircraft (see 1.18.1).

It continued taxiing on this course at between 8 and 10 kt. At 11:53:38 it began to slow down, reaching a minimum of 5 kt.

Starting at 11:54:02, its speed began to increase, reaching 10-11 kt.

At 11:54:21, it started a right turn to head north. The speed remained between 10 and 11 kt.

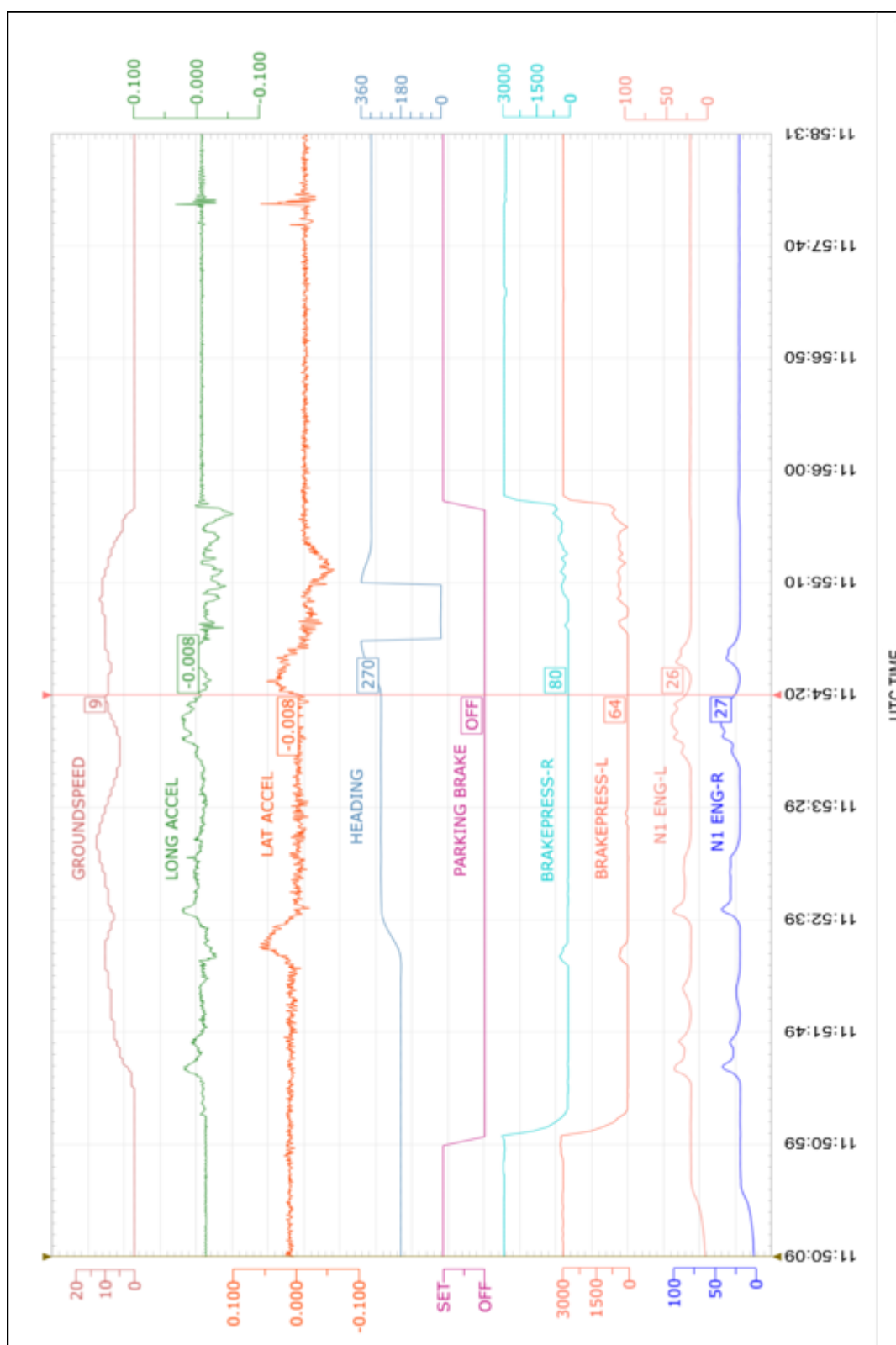


Figure 13. Graph of several parameters for aircraft N758AN, from 11:50:09 to 11:58:31 UTC

At 11:55:10, the aircraft started a left turn to course 314°. The aircraft continued on this heading until 11:55:43, when it stopped.

The parking brake was engaged 7 s later, at 11:55:50.

At 11:57:51, a slight increase in the longitudinal acceleration was recorded, as was a larger increase in the lateral acceleration, which peaked at 0.025 g (see Figure 13).

Eight seconds later, at 11:57:59, a second increase in the accelerations was recorded that was stronger than the first, with the lateral acceleration reaching a maximum value of 0.057 g.

1.11.2.2. Cockpit voice recorder

The aircraft was equipped with a Fairchild 2100 cockpit voice recorder, P/N 2100-1020-00 and serial number 000710315.

Five files were downloaded, four channels with high-quality audible information and one with medium to low quality information.

Before they began taxiing, the crew noted that the taxi route from their parking stand to the holding point for the runway in service was short. They informed the cabin crew of this so they could prepare the passenger cabin in time.

On the cockpit voice recorder, the crew appears focused on the taxi maneuver and expressed some doubts concerning the taxiways they were instructed to take, doubts that are reflected in their exchanges with ATC. They also held a takeoff briefing.

In the end, ATC provided them with turn-by-turn instructions to Z1 and transferred the crew to the tower frequency. Once at the holding point, the crew's conversation turned to operational aspects for their situation. They did not question if they were properly positioned at the holding point.

The crew of the American Airlines aircraft only became aware of the arrival of the Iberia aircraft when the latter first impacted the horizontal stabilizer, which was not a particularly strong collision. They realized the seriousness of the situation when the wings made contact, which is clearly heard on the cockpit voice recorder.

From then on the crew expressed their concern with informing the Iberia crew of the event, as well as with evaluating their own damage. They were perfectly aware that both their stabilizer and the left wing had been impacted.

After an inspection by ground personnel, they decided to taxi under their own power to a nearby parking stand. They requested to be escorted by RFFS to their assigned parking stand (580).

1.12. Wreckage and impact information



Figure 14. Photograph of aircraft N758AN on taxiway Z1, taken before it was moved and after being impacted by aircraft EC-LZX

Figure 14 shows a photograph of aircraft N758AN, taken at the site where the impact occurred before it was moved after the incident.

As the figure shows, the aircraft's nosewheel was a few meters beyond the category II/III holding point marking, though the photograph does not allow for a precise determination of this distance.

The fragments that detached during the event were found on the pavement in the vicinity of where the B3 to Z1 turn line and the line indicating the right edge of taxiway Z1 intersect.

The sketch in Figure 1 was drawn based on the above information and represents the approximate positions of the two aircraft at the time of the incident.

1.13. Medical and pathological information

Not applicable.

1.14. Fire

There was no fire.

1.15. Survival aspects

Not applicable.

1.16. Tests and research

1.16.1. Statements from the crews

1.16.1.1. Aircraft EC-LZX

1.16.1.1.1. Captain

The aircraft's captain stated that the workload during the flight had been heavier than usual, since they had been training an A-330 first officer for his first check-out flight, which had resulted in a "fatiguing flight".

At the time of the incident, the pilot seated in the RH seat was the qualified pilot, and not the one under instruction.

He stated that he noticed that the American Airlines aircraft was sticking out, and that he may have started his maneuver to deviate to the right a little late. He recalled that he had been reducing the speed because he was mindful of an A-340 aircraft that was taxiing to the holding point in the opposite direction, and was planning to leave it time to reach its position. He was trying not to stop the airplane, which would have required a significant increase in thrust to resume taxiing, which is contrary to the airline's fuel-saving policy.

ATC did not give them any instructions; rather, on two occasions they were cleared to pass and proceed to parking.

To avoid the American aircraft, which was not stopped at the right point, he steered a little to the right of the taxiway. As they passed alongside the aircraft, they felt a skip, as if the nosewheel had skidded.

He explained that from his position in the cockpit, he can see his own aircraft's wingtip but it requires straining his eyes to look to the side, which could affect his ability to distinguish objects in three dimensions since forcing his eyes to look to the side could diminish or eliminate the perception in one of his eyes (possibly the right). The captain admitted that he focused his attention on the American aircraft's wingtip, though he was not aware that they could also have impacted its horizontal stabilizer.

He stated that the markings at the Adolfo Suárez Madrid-Barajas Airport are bad, especially the horizontal markings, which can be hard to see if the surface is wet, especially at night. He also thought that the vertical markings were scarce.

The names of the taxiways are also complicated and not standard, as they do not use the terms inner and outer.

He thought the controller might have been able to see that the American Airlines airplane was out of position and instructed its crew to correct it.

He added that Iberia, in the wake of the incident, had conducted a FDM study and published a hotspot¹ for the area where the impact occurred.

1.16.1.2. Aircraft N758AN

1.16.1.2.1. Captain

He stated that he had taxied the aircraft to holding point Z1 for runway 36L, and that once there, he stopped the aircraft and set the parking brake. While they waited for the control tower to clear them to take off, their aircraft was struck, first in the right horizontal stabilizer and then in the right wingtip, by an Iberia A330 that was taxiing behind them. He reiterated that his aircraft was not moving since the parking brake was set.

¹ A hotspot is a zone in an airport that is made particularly problematic by the intersection of several taxiways or by impaired visibility.

They declared an emergency, informed the control tower and requested assistance. He made several announcements to the passengers and flight attendants to remain seated and calm. Ground personnel and a fire truck checked the damage and verified that no liquids were leaking out. He left the airplane in its existing configuration and made arrangements to return to parking. No passengers or crewmembers were injured.

Upon reaching parking, the passengers and crew were driven to another location by ground personnel.

As for the taxi instructions he had received from the GMC controller, he stated that, to his recollection, they were: runway 36L via M, B to Z1.

He had flown out of the Madrid Airport several times. In his opinion he was familiar with the airport and thought that his knowledge of its characteristics and configuration were adequate.

He underscored that he stopped the aircraft at Z1 far enough away to ensure sufficient separation from another aircraft that was at holding point Z3 and that was ahead of them in the takeoff sequence.

When asked if he knew that taxiway Z1 has two holding points for runway 36L, he answered yes, though he added that page 10-9C in the Jeppesen document only showed one holding point. He added that, as indicated on said chart, the holding point was a category II/III.

1.16.1.2.2. First officer and relief pilot

The statements from both were practically the same, and thus there is no need to detail them separately.

Both stated that the captain was taxiing the aircraft, which proceeded normally until they reached the runway 36L holding point ("hold short of Runway 36L"), where they waited to receive their takeoff clearance with the parking brake set. While they were waiting, an Iberia Airbus A330 struck the right horizontal stabilizer and the right wingtip on their aircraft.

After declaring an emergency, they kept the cabin crew and the passengers informed while ground personnel and firefighting personnel determined if they could taxi back to parking. They left the aircraft in its existing configuration and returned to parking. The passengers were driven away by ground personnel and the crew were taken back to their hotel.

1.17. Organizational and management information

1.17.1. *Aerodrome charts and information.*

1.17.1.1. General information

The information on air navigation services and airports is disseminated by individual States through their Aeronautical Information Service (AIS).

Air operators need to have updated aeronautical information on all the routes they fly. So if an airline has destinations in thirty different countries, it would constantly have to monitor the information issued by each and every one of the AIS for the thirty countries to which it flies, as well as by those issued by the countries whose airspace they cross. The information gathered would then have to be analyzed and incorporated into its flight documentation, a labor-intensive task that would require considerable resources.

Furthermore, the format of the documentation issued by AIS, which is in an ICAO standard, is not the best format for use in cockpits.

For these reasons, air operators, instead of having their own departments to handle this task, subcontract this service to specialized companies that provide them with the information they require in the formats best suited to their needs.

This information is added to Part C (ORO.MLR.101) of the Operations Manual of airlines, which the authority then accepts.

1.17.1.2. Jeppesen

American Airlines is no exception and has subcontracted this service to Jeppesen, a company that specializes in providing air operators with all of the aeronautical information they need to fly their aerial routes.

The documentation available to the crew of the incident aircraft was inspected. It was noted that on pages, 10-9C, "taxi routings", and 10-9E, the Z1 holding point is shown with a single holding point marking, as the crew of the American Airlines aircraft had stated (see 1.16.1.2).

Figure 17 shows a segment from page 10-9C, with the Z1 holding point indicated in a green circle.

As this figure shows, all of the holding points shown (Z1, Z2, Z3, Z4 and Z6) are indicated with a single holding point marking, although they all have two markings, one for CAT I and another for CAT II/III.

A review of Jeppesen's documentation on the Adolfo Suárez Madrid-Barajas Airport that the crew were using did not reveal any information concerning the note that is shown in the aerodrome ground movement chart, and which requires aircraft to taxi as close as possible to the runway holding points (see 1.10.2).

According to information provided by Jeppesen, the criteria it uses to represent holding points and stop bars on airport charts are as follows:

- CAT I and non-precision holding points:
These holding points are not usually shown on charts.
- CAT II and CAT III holding points:
 - o Are shown on the charts when specified by the source (of the information).
 - o The relevant symbol is placed across its associated taxiway.
 - o It is identified or labeled if it is "designated".
 - o No note is included in the legend.
 - o Designated stop bars or designated holding points.

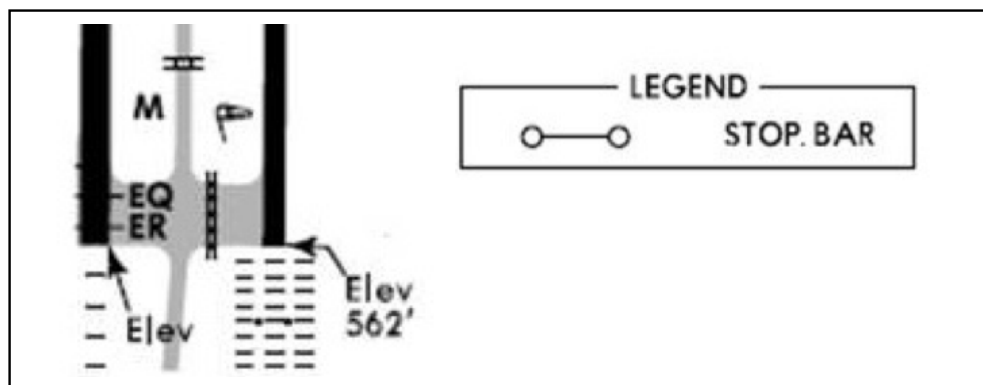


Figure 15. Examples of the holding point (left) and stop bar (right) symbols used by Jeppesen in its charts

For the purposes of this discussion, a designated stop bar or a designated holding point is one (different from ordinary CAT I, II/III or non-precision) that is identified using numbers, letters or a combination thereof.

1. Chart these positions per source.
2. The relevant symbol is placed across the taxiway, where indicated.
3. A label is included (see no. 5 for more information).
4. Stop bars are not shown unless they are referred to generally in a note (for example: lighted stop bars installed on the taxiway to runway 16R) and/or they have specific locations that are not indicated in the source.
5. When identified on source, label the position by placing the identifier along with the appropriate symbol.
6. For designated stop bars in the USA, a simple legend and a brief description of the system is also included.

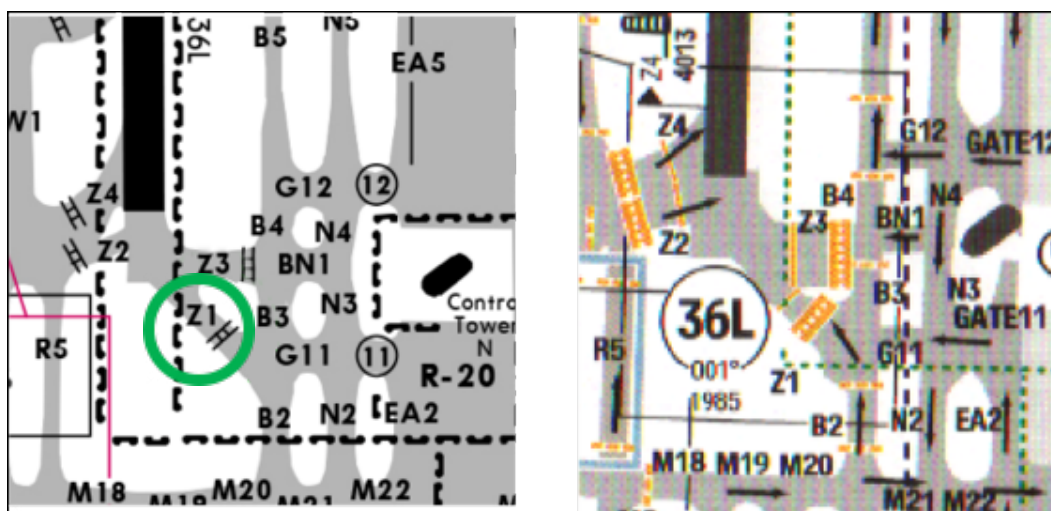


Figure 16. Portion of page 10-9C of the Jeppesen documentation (left) and of the AGC North chart from the LIDO documentation LIDO (right)

1.17.1.3. LIDO/NAVIGATION

Iberia uses the LIDO/NAVIGATION aeronautical information, which is supplied by Lufthansa Systems.

The information provided by LIDO on the Adolfo Suárez Madrid-Barajas Airport was reviewed. It was noted that the general part, on taxi and parking information, includes an instruction for aircraft to stop as close to runway holding points as possible.

The airport chart (see Figure 17) also shows both runway holding points, one for category I and the other for categories II/III.

1.17.2. Regulation of air navigation services providers

Aeronautical charts, as well as aeronautical information services, are regulated internationally in the International Civil Aviation Convention, and specifically in annexes 4 and 15 to the Convention, respectively.

In Europe, the provision of air navigation services is regulated by Commission Implementing Regulation (EU) No 1035/2011 of 17 October 2011, which lays down common requirements for the provision of air navigation services and amends Regulations (EC) No 482/2008 and (EU) No 691/2010.

Also, Commission Regulation (EU) No 73/2010 of 26 January 2012 lays down requirements on the quality of aeronautical data and aeronautical information for the single European sky.

Annex IV of the first of these contains the specific requirements for providing aeronautical information services.

These regulations refer solely to the Aeronautical Information Services (AIS) of countries.

The Aeronautical Information Services in Spain are provided by the state-run company ENAIRE.

Spain's National Aviation Safety Agency (AESA) has certified that ENAIRE is in compliance with the requirements specified in Annex IV of Regulation No 1035/2011 as a provider of aeronautical information services.

AESA audits ENAIRE's AIS services twice a year in terms of its procedures and products.

Companies that supply aeronautical data/information, such as Jeppesen, use the information prepared and published by the AIS of countries as sources of data when compiling the information they provide.

The aforementioned regulations only pertain to the supply of information by the AIS offices of countries, and are thus not applicable to providers such as Jeppesen.

There is currently no rule in the European Union that regulates this type of service, though work is ongoing on developing a specific regulation.

However, both EASA and the FAA have issued letters of acceptance in favor of Jeppesen, as specified below:

- EASA. Type 1 acceptance letter, which acknowledges compliance with the conditions for the EASA to issue acceptance letters for suppliers of navigation databases.
- FAA. Type I and II acceptance letters, which acknowledge compliance with AC 20-153A regarding the processing databases for airport movement maps.

1.17.3. *Visibility conditions*

Annex C of the control tower's Operations Manual contains the definitions for the various levels of visibility, which are as follows:

- Visibility condition 1 (VIS1): Visibility sufficient for the pilot to taxi and to avoid collision with other traffic on taxiways and at intersections by visual reference, and for personnel of control units to exercise control over all traffic on the basis of visual surveillance.
- Visibility condition 2 (VIS2): Visibility sufficient for the pilot to taxi and to avoid collision with other traffic on taxiways and at intersections by visual reference, but insufficient for personnel of control units to exercise control over all traffic on the basis of visual surveillance
- Visibility condition 3 (VIS3): Visibility sufficient for the pilot to taxi but insufficient for the pilot to avoid collision with other traffic on taxiways and at intersections by visual reference, and insufficient for personnel of control units to exercise control over all traffic on the basis of visual surveillance. For taxiing, this is normally taken as visibilities equivalent to an RVR of less than 400 m but more than 75 m.
- Visibility condition 4 (VIS4): Visibility insufficient for the pilot to taxi by visual guidance only. This is normally taken as an RVR of 75 m or less.

According to this, the controllers must provide instructions that ensure aircraft separation when the existing visibility conditions are equal to or worse than VIS 3.

1.18. Additional information

1.18.1. *Radar information*

The investigators reviewed the radar system recordings from 11:35:14 UTC until the time of the incident.

According to this information, aircraft N758AN, callsign AAL37, which was parked at stand 580, commenced pushback away from said stand at 11:48:50 UTC.

After the pushback maneuver, the aircraft was facing south. It started moving in that direction, continuing on taxiway EB2 and then EB1.

At 11:52:25, it made a right turn to continue taxiing on taxiway A23 and then on A22 and A21. At 11:54:29, it turned right to continue on taxiway B1. At that same time, aircraft IBE6463 was turning from taxiway N4 to BN1, which connects directly to the runway access taxiway Z3.

Aircraft IBE6463 was an Airbus A-340-300.

Aircraft AAL37 taxied on taxiways B1 and B2, reaching the intersection with taxiway Z1 at 11:55:12. At that time, aircraft IBE6463 was crossing taxiway B4 as it taxied on BN1 to Z3.

Some 3 s later, aircraft AAL37 started to turn onto taxiway Z1. Aircraft IBE6463 was practically stopped at the intersection of BN1 and B4.

At 11:55:48, aircraft AAL37 stopped inside taxiway Z1. It did not move until after the incident. Aircraft IBE6463 was still stopped at the entrance to taxiway Z3.

Figure 18 shows a reproduction of the multilateration radar image from that instant, with the labels for the two aircraft circled in red.

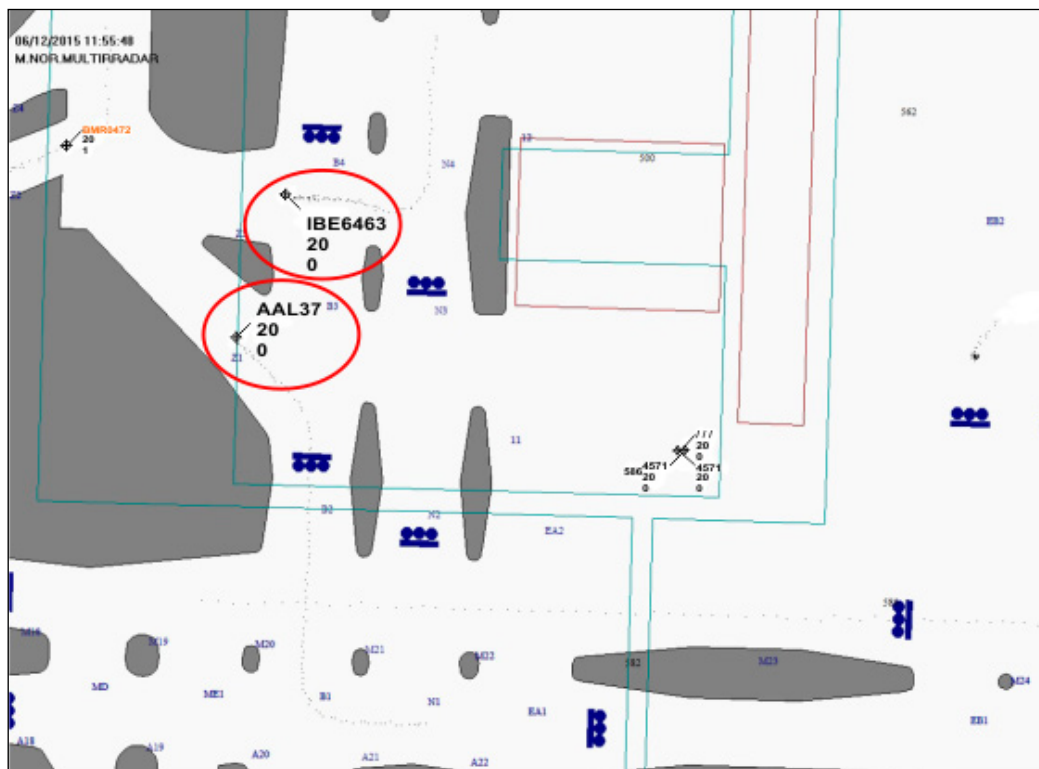


Figure 17. Multilateration radar image from 11:55:48

Thirty-seven seconds later, aircraft IBE6463 started to move to the inside of taxiway Z3, stopping again at 11:57:17, fully within taxiway Z3.

At that point, aircraft EC-LZX, callsign IBE6118, was taxiing on taxiway B2. Aircraft N758AN, callsign AAL37, was stopped on taxiway Z1.

The image also shows another aircraft, with callsign BMR9472, at the threshold of runway 36L, which had not commenced its takeoff run yet.

The image in Figure 19 shows a section of the radar screen from 11:57:45 UTC, which is practically the same time when the event occurred. This image shows that aircraft IBE6463 was closer to runway 18R-36L than aircraft AAL37 was.

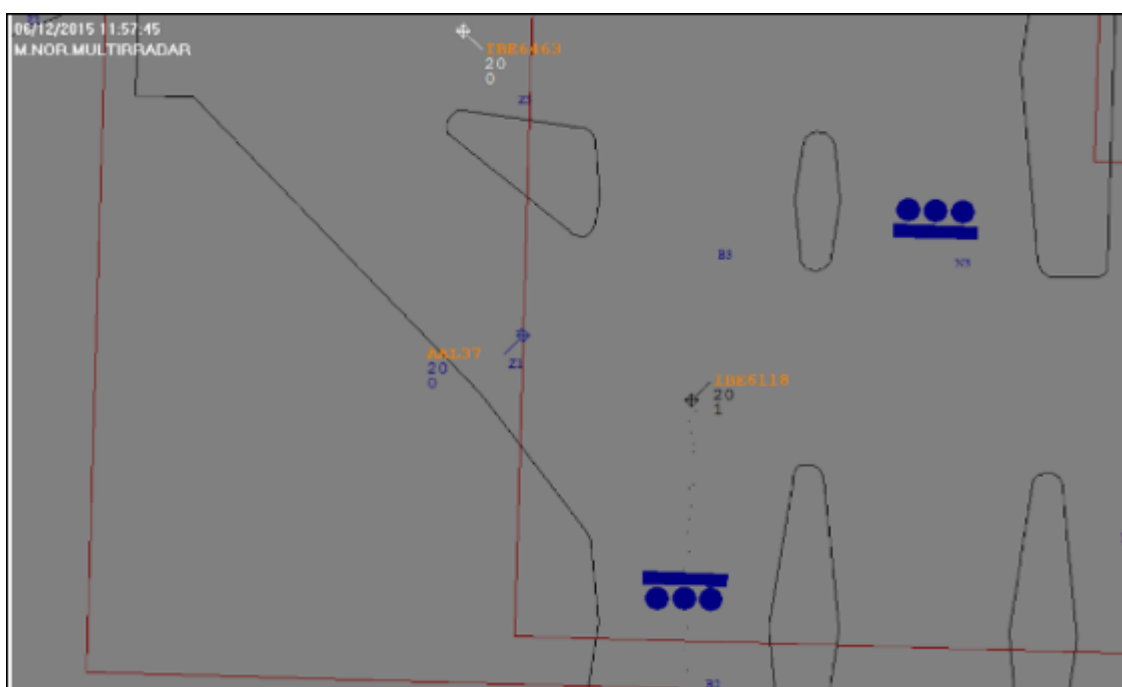


Figure 18. Multilateration radar image from 11:57:45

1.18.2. Regulation for aerodrome control services

Aerodrome control services are regulated in Chapter 5, Book IV of Spain's Air Traffic Regulations (RCA), published by Royal Decree 57/2002, as well as by its subsequent amendments.

The functions of the aerodrome control service are specified in point 4.5.1, "General", as follows:

4.5.1. GENERAL.

4.5.1.1. The aerodrome control service shall relay information and issue clearances to aircraft under its control so as to achieve the safe, orderly and fast movement of air traffic in the aerodrome and its vicinity, for the purpose of preventing collisions between:

- a) aircraft flying inside the designated area of responsibility of the control tower, including the aerodrome traffic patterns around the aerodrome;
- b) aircraft operating in the maneuvering area;
- c) aircraft that are landing and taking off;
- d) aircraft and vehicles operating in the maneuvering area;
- e) aircraft in the maneuvering area and any obstacles in said area.

4.5.1.2. The functions of the aerodrome control service can be provided by various control or work stations, such as:

- a) aerodrome controller, normally responsible for runway operations and for aircraft flying inside the area of responsibility of the aerodrome's control tower;
- b) ground movement controller (1), normally responsible for traffic in the maneuvering area, except for runways;
- c) clearance delivery controller, normally responsible for delivering start-up and ATC clearances for departing IFR flights.

4.5.1.3. Aerodrome controllers shall keep under constant surveillance all flight operations that take place in the aerodrome or in its proximity, as well as all vehicles and persons who are in the maneuvering area. They shall be surveyed visually, subject to assistance, especially in low-visibility conditions, provided by means of an ATS surveillance system if available. Traffic shall be monitored as per the procedures provided in this book, and traffic in all aerodromes within said area shall be coordinated so as to avoid interference between traffic patterns.

The instructions on controlling aerodrome traffic are contained in section 4.5.6, the most significant points of which, for the event analyzed in this report, being the following:

4.5.6.1. General. Since the field of view from the pilot's position in an aircraft is normally restricted, the controller shall ensure that the instructions and information involving those elements that require the flight crew to rely on visual detection, recognition and observation are expressed clearly, concisely and completely.

4.5.6.4.1.1. Before issuing a taxi clearance, the controller shall ascertain where the aircraft in question is parked. The taxi clearance shall include concise instructions and sufficient information to help the flight crew determine the proper taxi route, avoid collisions with other aircraft or objects and minimize the possibility that the aircraft will inadvertently enter an active runway.

1.18.3. Measures taken by AENA

This event was studied by the airport's Operational, Quality and Environmental Safety Division, which issued its report in April of 2016. It describes the measures that had already been taken by the airport in an effort to minimize this kind of event, as well as other additional measures.

- Measures adopted:
 - o Modification to holding points (approved in October 2015). The existing CAT II/III holding points on the four runways will be removed, due to their

exclusive use. The CAT II/III holding points for runway 18L-36R will be removed in the spring of 2017. The actions involving the remaining points to be removed will be carried out in subsequent years. There are no detailed plans as of the writing of this report.

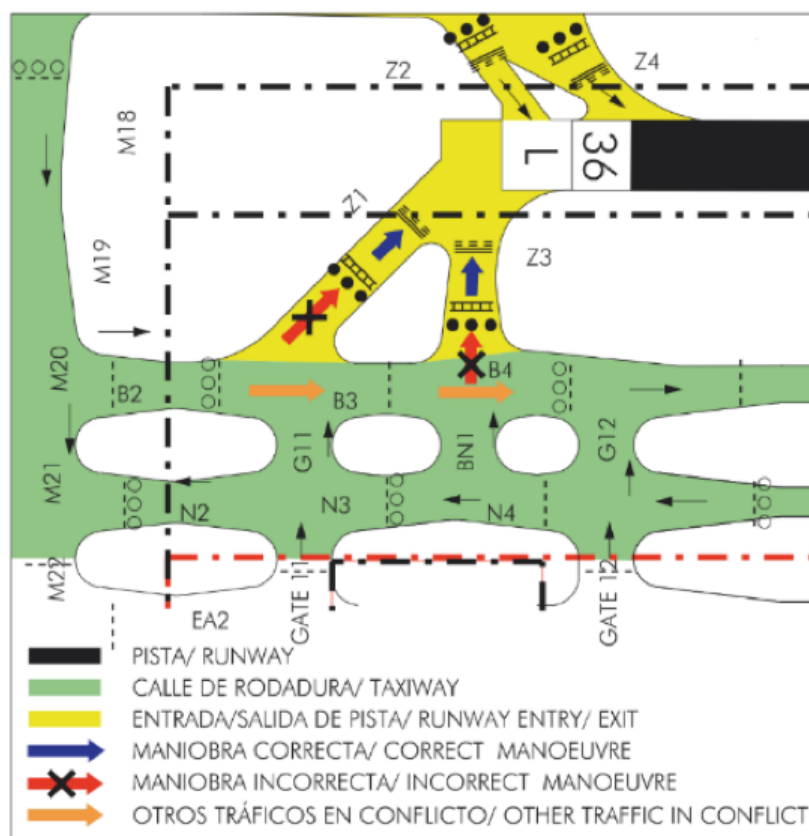


Figure 19. Information on the hotspot for holding points Z1 and Z3 published in AIP-Spain

- o Until the holding points are modified, the holding points LA, LB, Z1 and Z3 will be included in the listing of hotspots in the AIP.

The AIRAC amendment, AMDT AIRAC 06/18, published on 09/06/2016, which goes into effect on 21/07/2016, includes information on the hotspot at holding points Z1 and Z3 (see Figure 20).

In addition to the diagram in Figure 20, the information on this critical point includes the following text:

"Aircraft approaching runway holding points must stop AS CLOSE AS POSSIBLE TO THE RUNWAY HOLDING POINT to allow greater clearance for traffic taxiing behind them on TWY B. Aircraft taxiing on TWY B with aircraft at the Z3 runway holding points must ensure there is no conflict before passing behind them. If in doubt, they must wait near TWY Z1 or Z3."

- o A circular has been sent to all the airlines that operate at the airport, asking them to remind their crews of the instructions contained in point 11 of section AD 1.1 of the AIP (see Figure 8).

1.18.4. *Measures taken by Iberia*

In the wake of the incident, Iberia conducted an FDM study, published a hotspot for the area where the impact took place and issued a memo on the incident to its crews through the channels made available by the Safety Management System.

1.18.5. *Measures taken by American Airlines*

American Airlines distributed the information on this event to its crews through its Safety Management System (SMS).

1.19. Useful or effective investigation techniques

Not applicable.

2. ANALYSIS

2.1. Analysis of the geometric configuration and the markings in the area of the event

The specifications for the width of the taxiways contained in R.D. 862/2009, in ICAO Annex 14 and in the EASA's CS-ADR-DSN all agree, with the minimum value being 23 m for code letter E taxiways and 25 m for code letter F taxiways.

Taxiways Z1, Z3, B2 and B3 are at least as wide as required by the technical regulations.

The separation between the centerline of taxiway B and the centerline of runway 18R-36L is 192 m, just over the 190 m required by the regulation.

The runway holding points must be located a minimum distance away from the runway centerline. This value depends on the classification code and the approach type.

Minimum distance between the centerline of a runway with code number 4 and the runway holding point	Distance
Visual approach runways	75 m
Non-precision approach runways	75 m
Category I approach runways	90 m
Category II/III approach runways	90 m ^(a)
Takeoff runways	75 m

^(a) When the code letter is F, this distance shall be 107.5 m

The category I runway holding point on taxiway Z1 is located some 80 m away from the runway centerline, while the category II/III point is 127 m away.

The category I holding point on taxiway Z3 is 75 m away from the runway centerline and the category II/III point is 120 m away.

The locations of the CAT I and CAT II/III holding points on both taxiways satisfy the minimum distances specified in the regulation.

So as to evaluate the existing separation between the category I holding points on taxiways Z1 and Z3 and taxiway B, we will assume that there is a B-777-200 aircraft, measuring 63.7 m in length, stopped at each of these points.

Holding point Z3 is 120 m away from the taxiway B centerline. If there were a B-777-200 aircraft stopped atop the holding point marking, its aft end would be 56.5 m away from the taxiway B centerline, meaning it would be slightly encroaching on the taxiway strip, which measures 57.5 m, as per the applicable technical specifications at the time (RD 862/2009).

In contrast, if the technical specifications of the CS-ADR-DSN are applied, which specify a minimum width of 51 m for taxiways with code letter F, proper clearance would be maintained.

In the case of holding point Z1, the aft end of a B-777-200 aircraft would be some 60 m away from the runway B centerline, meaning it would satisfy the requirements of both technical specifications.

If, however, instead of the 200 version of the B-777 aircraft we consider the 300 version, which is a little over 10 m longer, this aircraft would encroach on taxiway B at both the Z1 and Z3 holding points applying either technical specification.

The safety margins included in the technical specifications mean that even if the minimum separations are not satisfied, there will be no significant operational incident if the violation is minor.

For a B-777-300 stopped at the Z3 runway holding point and the maximum wingspan aircraft (which would be up to 80 m) taxiing on taxiway B, the clearance between the two aircraft would be 6.10 m.

Taxiways Z1, Z2 and B are certified by AESA for operations with category-F aircraft.

During an airport's certification process, both its physical characteristics and its aeronautical operations are evaluated as a single infrastructure/operational group.

Therefore, in addition to the physical features analyzed in the preceding paragraphs, the operating procedures that complement them have to be taken into consideration as well.

As noted in point 1.10.8, the airport's operating instructions do not allow aircraft to be stopped at holding point Z1 or Z3 if there is a category-F aircraft taxiing on taxiway B, thus sidestepping the non-compliance with the technical specifications indicated earlier.

In light of the above, we may conclude that the area where the incident analyzed in this report occurred is properly certified for operations with category-F aircraft.

The markings for both the CAT I and the CAT II/III holding points on the two taxiways satisfy the technical regulations in effect at the time, RD 862/2009, which in turn coincide with those contained in ICAO Annex 14.

It should also be noted that these markings, in terms of their format and layout, are identical to those specified by the regulations in effect in the United States.

The fact that the markings satisfy the regulatory specifications does not mean they are required or even appropriate. Having too few markings is as detrimental as having too many.

Runway 18R/36L has a fixed use. Runway 18R is only used for landings (south configuration) and runway 36L only for takeoffs (north configuration). Therefore there are no takeoffs in this runway with south configuration as well as there are no landings with north configuration.

CAT II/III holding points on taxiways Z1 and Z3 would serve to indicate the place where an aircraft must stop before entering runway 36L to take off, in case CAT II/III landings were taking place in that runway. Since the use of the runway is fixed as above indicated, this situation is not possible to happen.

As a result, at a minimum the CAT II/III holding point markings on taxiways Z1 and Z3 at the airport are unnecessary and could be removed.

2.2. Analysis of the taxi maneuver and of the aircraft's positions at the time of the collision

As stated in point 1.18.1, aircraft N758AN started to push back from its parking stand at 11:48:50 UTC.

The GMC-NE controller instructed the crew to taxi to taxiway A, which entailed taxiing south on taxiway EB2 and then EB1 to reach taxiway A.

Although this route differs from the standard route, it is in keeping with procedures, which allow the controller to issue different taxi instructions.

In this case, the controller decided to provide an alternate route that considerably reduced the distance to be traveled by the aircraft, which the traffic conditions allowed. The taxi maneuver to the site of the incident was normal.

When aircraft N758AN, taxiing on taxiway B2, reached the intersection with Z1, aircraft IB6443 was stopped at the intersection of taxiways BN1 and B4, and the

entrance to taxiway Z3 but not having yet entered it, or possibly with only the front part of the airplane.

This aircraft did not move while aircraft N758 AN entered taxiway Z1, taxied along it and stopped, moving no further until after the event.

After aircraft N758AN stopped, aircraft IB6443 continued advancing on taxiway Z3 until it reached the CAT I holding point.

From this we can infer that when aircraft N758AN entered taxiway Z1 and continued taxiing, there was no aircraft on taxiway Z3.

The fact that taxiway Z1 is at an angle to Z3 means that as an aircraft advances toward runway 36L, the separation between aircraft at these two points diminishes. This circumstance could have conditioned the crew's decision to stop the aircraft where they did.

Although no precise information is available on where it stopped, there are sufficient data to narrow down its location with considerable accuracy.

As noted in point 1.12, the photograph of the aircraft taken before it moved reveals that its nosewheel was a few meters beyond the category II/III holding point marking. The fragments that detached during the event were found on the pavement in the vicinity of the place where the B3 to Z1 turn line and the extended right edge line for taxiway Z1 would intersect.

The edge line for taxiway Z1 has been extended in the image in Figure 21 to determine where it intersects the taxi marking. The wingtip of aircraft N758AN should be approximately over this point.

This same figure shows aircraft N758AN such that its right wingtip is over the intersection of the markings specified in the above paragraph. In this position, the front part of the aircraft would be some 40 m away from the holding point marking.

Since the CAT I and CAT II/III markings are 60 m apart, it follows that under these conditions, the front of the airplane was 20 m forward of the CAT II/III marking.

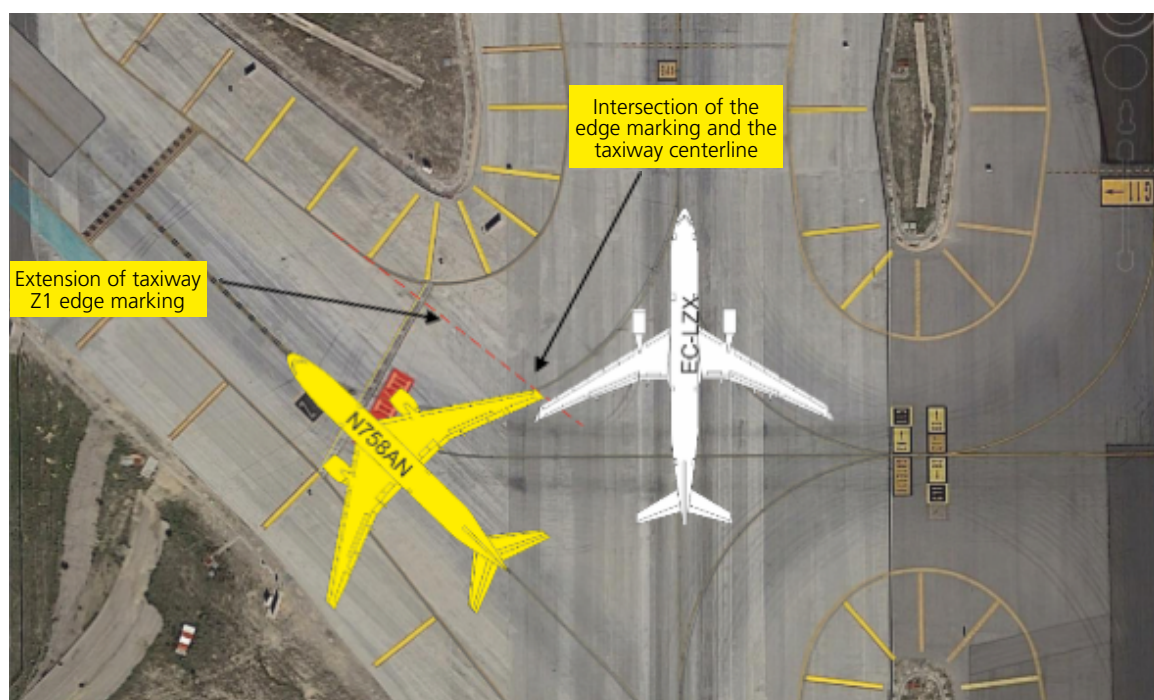


Figure 20. Diagram of the probable positions of the two aircraft at the time of the collision

The nosewheel is 5.89 m behind the front tip of the aircraft, meaning that under the conditions in question it would have been 14 m forward of the CAT II/III marking.

Since the position shown in Figure 21 is consistent with the information available, it may be deduced that these were the actual locations of the aircraft at the time of the collision, within a small margin of error.

2.3. Taxi specifications involving runway holding points

No specification or instruction was found in the applicable regulation as to how far from a taxi or runway holding point marking an aircraft must stop.

Airport designers normally calculate the dimensions of different parts of an airfield assuming that aircraft stop exactly at the holding points. The distances specified in the technical regulations include safety margins that protect against the risk that aircraft will stop several meters before reaching these markings, and that are sufficient to mitigate any potential deviations.

But when an aircraft stops a long distance away from a marking, this can result in an incident involving airport operations since the aircraft could be blocking or impeding taxi maneuvers on another taxiway, which would force aircraft taxiing on it to stop.

This will naturally have a direct effect on several aspects: operational safety, by violating safety margins; on-time performance, by affecting the flow of traffic; airport capacity, by restricting traffic; environmental and financial, since putting an aircraft in motion after stopping entails additional fuel consumption, and so on.

As a result, it is important that aircraft stop as close as possible to holding points.

This is also the reason why the airport operator decided to include in the aerodrome ground movement chart a note on the requirement for aircraft to stop as close to runway holding points as possible.

2.4. Analysis of the aeronautical information

As discussed in point 1.17.2, there is still no regulation in Europe that governs the services rendered by providers of aeronautical information companies like Jeppesen, though such a regulation is being drafted.

The airport information being used by the crew of the American Airlines aircraft, prepared by Jeppesen, only included a single holding point, which is consistent with the criteria commonly employed by that company.

Since the normal practice of this company is not to show CAT I holding points on airport charts, and to only include information on holding points when they are of the CAT II/III variety, it is somewhat striking that the crew of N758AN was surprised by this.

Jeppesen's information on the airport also included no mention of a note contained in the aerodrome ground movement chart published in AIP-Spain (see 1.10.2), which states that "aircraft shall taxi as close as possible to runway and intermediate holding points...", and thus the crew of aircraft N758AN were unaware of this requirement.

In contrast, the LIDO information did contain information on this requirement, in addition to showing both holding points (CAT I and CAT II/III) on the AGC North chart.

As discussed in the previous point (2.3), stopping excessively far away from holding points can have direct effects on airport operations. As a result, the information in the note contained in the airport chart referred to in the paragraph above is operationally relevant, and as a result should be included in the airport information published by Jeppesen.

It is possible that this is not an isolated occurrence, and that there are additional important notes or information on the Madrid-Barajas and other Spanish airports that have not been included in the documents published by Jeppesen.

For this reason, this report includes an operational safety recommendation directed at Jeppesen to have it review the information published in AIP-Spain that is not included in its documentation and that it incorporate that which may have an effect on operations, such as the note in the airport chart discussed in this report.

2.5. Analysis of taxi responsibilities assigned

The aerodrome control service is responsible for providing information and clearances to aircraft under its control so as to achieve the safe, orderly and fast movement of air traffic in the aerodrome.

This means that in the case of taxi clearances, the controller has to provide instructions that comply with these requirements. Put simply, the controller has to instruct an aircraft crew to follow a taxi route that, based on the information available at that time, will reasonably satisfy those requirements.

What the controller is not responsible for, however, is ensuring separation between a taxiing aircraft and other aircraft, vehicles or other objects in good visual conditions.

Only under low-visibility conditions, VIS 3 and VIS 4, when the pilot is visually unable to avoid collisions, is the controller responsible for ensuring separation. In such cases, the low-visibility procedures are activated. These include, among other measures, severe restrictions on the airport's operating capacity and make tools available to controllers at the aerodrome so as to enable them to separate aircraft.

The visual conditions on the day of the event were ideal, meaning that crews were responsible for maintaining adequate separation between their aircraft and other aircraft, vehicles or obstacles.

In addition, the responsibilities of an aerodrome controller include that of constantly watching all flight operations that take place at the airport, including taxi operations, which would include aircraft stopping at holding points. Although this does not require controllers to monitor each and every movement, it does require them to remain vigilant.

Included in the information on the hotspot in the vicinity of taxiways Z1 and Z3 that was published in the AIP as a consequence of this incident is a requirement for aircraft to stop as close as possible to holding points.

In light of this, and of the importance that an aircraft stopped too far away from a holding point marking can have, and of the publication of a new hotspot at Z1 and Z3, it seems prudent that controllers be particularly vigilant of these areas so they can detect these situations and instruct aircraft crews to move forward and stop closer to the holding point marking.

These actions will help make crews more mindful of the locations where they stop their aircraft, which will contribute to improving operations and safety at the airport.

For this reason, an operational safety recommendation is included directed at the aerodrome's control service provider, Enaire, to have it instruct the aerodrome controllers to be more vigilant of runway holding points so that when they detect an aircraft that is stopped an unsafe distance away from holding markings, they instruct its crew to move closer to the marking.

2.6. Analysis of the mitigation measures taken

Both operators provided information on this incident to their crews.

In addition, after analyzing the event, Iberia deemed it appropriate to consider the incident area as a hotspot, informing its crews of this determination.

These actions are viewed as positive, since merely by having crews become aware of incidents of this type helps raise their awareness of the importance of maintaining sufficient separation with other aircraft during the taxi phase.

As noted in point 2.1, the CAT II/III holding points are not required as these are dedicated runways. As a result, the conclusion reached by the airport operator, AENA, to remove the CAT II/III holding points from all runways is deemed entirely correct.

Also considered correct is the designation of the incident site as a hotspot and its subsequent publication in the AIP, until the holding point markings can be removed. This action can be expected to help the crews that operate at the airport be more aware of the need to adjust the location where they stop their aircraft at holding points, which will improve operational safety at the airport.

2.7. Analysis of the operation

The crew of N758AN, with radio callsign "American 37" (AAL037), started to taxi from parking stand 580. They received non-standard taxi instructions that shortened

the distance to holding point Z1. They realized that the taxi maneuver would be short, so they notified the cabin crew to expedite their cabin preparations and the passenger briefing.

During the taxi maneuver, some questions arose as to how to properly comply with the instructions received, which they clarified with ATC. The crew stated that the taxiways were not marked very well and noted the oddity that at this airport you can turn 90° and still be on the same taxiway.

Despite the captain's previous operational experience at the Adolfo Suárez Madrid-Barajas Airport, the crew's comments and concentration during the taxi phase indicate some uncertainty.

During the taxi maneuver, the crew held the takeoff briefing and conducted normal pending procedures.

As they neared holding point Z1, they were informed by the taxi controller that this taxiway would be the first on their left.

The crew stopped the aircraft just beyond the CAT II/III holding point, which would have been the reference holding point had the airport been operating under low-visibility procedures, which was not the case on that day due to the good weather conditions.

In his statement, the captain indicated that he stopped the aircraft at that position in Z1 far enough away to ensure safe separation with another aircraft that was at Z3, and which preceded them in the takeoff order. The crew are not heard making any comments in this regard in the cockpit voice recorder. In addition, the multilateration display (Figure 18) shows that AAL037 reached point Z1 before IBE6463 reached holding point Z3.

The captain also admitted that he was aware of the presence of the CAT I holding point, even though he stated that in its chart, Jeppesen only shows a single holding point.

The investigation confirmed the finding that Jeppesen only shows CAT II/III holding points in its charts. The two holding points are only shown if they have different names.

The AIP publication for the airport instructs that "aircraft shall taxi as close as possible to runway and intermediate holding points, since clearance behind said points is not guaranteed (see AD 1.1). It is an aircraft captain's responsibility to

watch their surroundings and take measures to avoid collisions with other aircraft and to inform ATC when they cannot comply with a requirement”.

This information was not included in the Jeppesen documentation that the crew of AAL037 were using as a reference.

The captain of IBE6118 stated that there had been more workload during the flight than usual since they had been training one of the first officers. At the time of the incident, the first officer who was helping him with the maneuver was not the trainee, but a first officer who was qualified on the aircraft.

Although he noticed the aft position of the American Airlines aircraft, he was monitoring an Iberia A-340 that was taxiing on taxiway N in the opposite direction and heading toward the runway 36L holding point, which caused him to reduce his taxi speed.

According to the DFDR recording, the captain turned the steering wheel right some 25 seconds before the impact. This correction could have been intended to steer away from the obstacle posed by the aircraft that was stopped on Z1, but it translated into a course deflection of less than 2° (magnetic heading 004°) from the previous course.

According to the CVR recording, the first officer proposed informing the control tower of the unusual position of the American Airlines aircraft, but the captain thought they had enough room to maneuver around and avoid it.

During the interview, he stated that his intention was to avoid having to stop the aircraft, since a significant amount of thrust would have been required to resume taxiing, which is contrary to the airline’s fuel saving policy. It also results in increased noise.

He explained that from his position in the cockpit, he can see his own aircraft’s wingtip but it requires straining his eyes to look to the side, which could affect his ability to distinguish objects in three dimensions since forcing his eyes to look to the side could diminish or eliminate the perception in one of his eyes. This could have contributed to his misjudging the maneuver to avoid hitting the stopped aircraft.

In any event, the captain admitted that he focused his attention on avoiding the American aircraft’s wingtip, though he was not aware that they could also have impacted its horizontal stabilizer.

This investigation acknowledges the difficulty of a taxi maneuver when attempting to calculate subjectively if an obstacle can be avoided, especially in a large aircraft. The airport design regulation also identifies this problem and ensures the safety of ground movements by classifying taxiways based on the wingspan of the aircraft that are likely to use the facilities.

The most appropriate maneuver if in doubt as to whether an obstacle can be avoided is to stop the aircraft and request assistance from airport services, either ATS or ground personnel.

3. CONCLUSIONS

3.1. Findings

- All of the crew members on both aircraft had valid licenses and medical certificates.
- The GCM CENTRAL-NORTH and LOCAL 36L ground controllers had valid licenses and medical certificates.
- The documentation for the two aircraft was valid and they were airworthy.
- Aircraft N758AN was cleared to taxi to holding point Z1 for runway 36L to commence a flight to the Dallas-Fort Worth Airport (United states).
- When aircraft N758AN reached taxiway Z1, aircraft IB6443 was stopped at the intersection of taxiways BN1 and B4.
- While aircraft N758 AN taxied on taxiway Z1, aircraft IB6443 was stopped at the intersection of taxiways BN1 and B4.
- Aircraft N758AN stopped 20 m beyond the CAT II/III holding point, but 40 m before reaching the marking for the CAT I holding point.
- The documentation for the airport published by Jeppesen, which the crew of aircraft N758AN were using, did not contain a note from the aerodrome chart for ground movements-ICAO stating that "aircraft shall taxi as close as possible to runway and intermediate holding points...".
- Aircraft EX-LZX had just landed, inbound from the Miami Airport (United States), and had been cleared to taxi on taxiway B.
- The crew of aircraft EC-LZX realized that aircraft N758AN was very close to taxiway B and that there was little room to taxi behind it.
- The controller did not warn the crew of aircraft N758AN about their position at the holding point or instruct them to move forward.
- The captain of aircraft EC-LZX thought that the space available was sufficient to allow his aircraft to pass behind aircraft N758AN.
- The left winglet struck the right elevator and then the right wingtip on aircraft N758AN.

3.2. Causes/Contributing factors

This incident occurred due to the decision of the crew of aircraft EC-LZX to continue taxiing behind aircraft N758AN despite realizing that the latter was very close to the taxiway on which they were taxiing.

The following factors contributed to this incident:

- The fact that aircraft N758AN stopped 40 m away from the runway 36L holding point marking, and by doing so encroached on the strip of taxiway B.
- The omission in the airport information prepared by Jeppesen of the note in the aerodrome chart for ground movements-ICAO published in the AIP-Spain stating that "aircraft shall taxi as close as possible to runway and intermediate holding points".

4. SAFETY RECOMMENDATIONS

REC. 15/17. It is recommended that Jeppesen review the information published in the AIP-Spain that is not included in its documentation, and that it incorporate which could be operationally important, such as the note in the airport chart indicated in this report.

REC. 16/17. It is recommended that Enaire instruct aerodrome controllers to redouble their monitoring, including visual, of runway holding points and that when they detect an aircraft that is stopped an unsafe distance away from holding markings, they instruct its crew to move closer to the marking.