Report

IN-009/2016

Incident involving an Airbus A-320-232 aircraft, registration EC-MGE, at the Bilbao Airport on 28 March 2016

MINISTERIO DE FOMENTO

SUBECRETARÍA

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 (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) nº 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.

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

CONTENTS

ABBREVIATIONS

ADR	Air data reference
AGL	Above ground level
ADIRU	Air Data Inertial Reference Unit
AOA	Angle of attack
AENA	Aeropuertos Españoles y Navegación Aérea (Spanish airports and air navigation)
AFM	Aircraft Flight Manual
AP	Autopilot
APP	Approach
ATC	Air traffic control
ATS	Air Traffic Service
A/THR	Autothrottle
ATPL	Airline transport pilot license
BSCU	Brake system control unit
CAS	Calibrated airspeed
CIAIAC	Civil Aviation Accident and Incident Investigation Commission
CM	Crewmember
CVR	Cockpit voice recorder
D	Days
EASA	European Aviation Safety Agency
ELAC	Elevator and aileron computer
EW	Empty weight
FC	Flight cycles
FCOM	Flight Crew Operations Manual
FCTM	Flight Crew Training Manual
FDR	Flight data recorder
FH	Flight hours
FOLD	Factored operational landing distance

Ft	Feet
ft/min	Feet per minute
FL	Flight level
FMS	Flight management system
g	Gravity
GS	Glide slope
H	Hours
HPa	Hectopascals
IAF	Initial approach fix
IFR	Instrumental Flight Rules
ILS	Instrument landing system
IR	Instrument rating
JAR-FCL	Joint Aviation Requirements- Flight Crew License
Kg	Kilograms
Km/h	Kilometers per hour
Kt	Knots
LDA	Landing distance available
LEBB	Bilbao Airport (ICAO code)
LH	Left hand
LOC	ILS localizer
m	Meters
METAR	Meteorological terminal air report
Mhz	Megahertz
min	Minutes
MTOW	Maximum takeoff weight
NM	Nautical miles
NWS	Nosewheel steering
OFP	Operational flight plan
OM	Operations Manual
PAPI	Precision Approach Path Indicator
PF	Pilot flying

PFD	Primary flight display
PFR	Post-Flight Report
PIREPS	Pilot reports
PM	Pilot monitoring
QRH	Quick Reference Handbook
QNH	Atmospheric pressure (Q) at nautical height – Altimeter subscale setting to obtain elevation when on the ground.
RH	Right Hand
RWS	Reactive windshear system
S, sec	Seconds
SEC	Spoiler elevator computer
SRS	Speed reference system
SW	Southwest
TAF	Terminal Aerodrome Forecast
TDZE	Touchdown zone elevation
TLA	Thrust Lever Angle
VMA	Maximum speed of the instantaneous speeds recorded in the 10 previous minutes
VMD	Average of the instantaneous speeds recorded in the 10 previous minutes
UTC	Coordinated universal time
Vapp	Approach speed
VLS	Lowest selectable speed

SYNOPSIS

Owner and Operator: Vueling

Aircraft: Airbus A-320-232, registration EC-MGE

Date and time of incident: 28 March 2016 at 06:52 UTC

Site of incident: Bilbao Airport (LEBB), Spain

Persons onboard: 6 crew and 109 passengers. None injured.

Type of flight: Commercial air transport - Scheduled - Domestic - Passenger

Phase of flight: Landing – Landing run

Flight rules: IFR

Date of approval: 30 January 2019

Summary of Incident.

On Monday, 28 March 2016, an Airbus A320-232 aircraft, registration EC-MGE, was involved in an incident while landing on runway 30 at the Bilbao Airport (LEBB). The airplane was inbound from Barcelona and had 115 occupants onboard.

After an initial missed approach, the aircraft landed on runway 30 at the Bilbao Airport. During the landing run, the airplane was unable to remain on its heading and exited the runway via the left shoulder, momentarily taxiing over an unpaved area with the left main gear before returning to the runway and subsequently stopping on the taxiway.

The occupants were not injured and the aircraft and airport facilities sustained minor damage.

1. FACTUAL INFORMATION

1.1 History of the flight

The Bilbao Airport had been on alert due to surface winds from 27 March 2016 at 21:00 UTC until Monday, 28 March 2016 at 06:00 UTC.

The aircraft, an Airbus A320-232, registration EC-MGE, which was inbound to the Bilbao Airport from the Barcelona Airport with 115 occupants onboard, had executed a go-around due to windshear on runway 30 at the airport at 06:20 UTC.

After receiving vectors from ATC, it entered a hold at point SARRA (IAF[1]), where it circled once before initiating the second approach.

The aircraft then landed on runway 30 at the Bilbao Airport. It was a normal landing until, during the landing run, the crew were unable to maintain the path, with the aircraft veering from side to side on the runway before eventually leaving the runway via the left shoulder between exit taxiways 5 and 6. The aircraft then momentarily taxied over an unpaved area with its left main gear before returning to the runway, which it then exited via taxiway C6. The aircraft then came to a stop on taxiway T, just before taxiway C5 (see Fig. 1).

The tower dispatched the firefighting service, which took a reading onsite of the main gear brake temperature, which was normal. The firefighting service then escorted the aircraft to parking stand no. 1 on the apron, where they again checked the temperature and carried out a visual inspection of the aircraft.

The occupants were not injured and the aircraft and airport facilities sustained minor damage.

[1] IAF.- Initial aproach fix

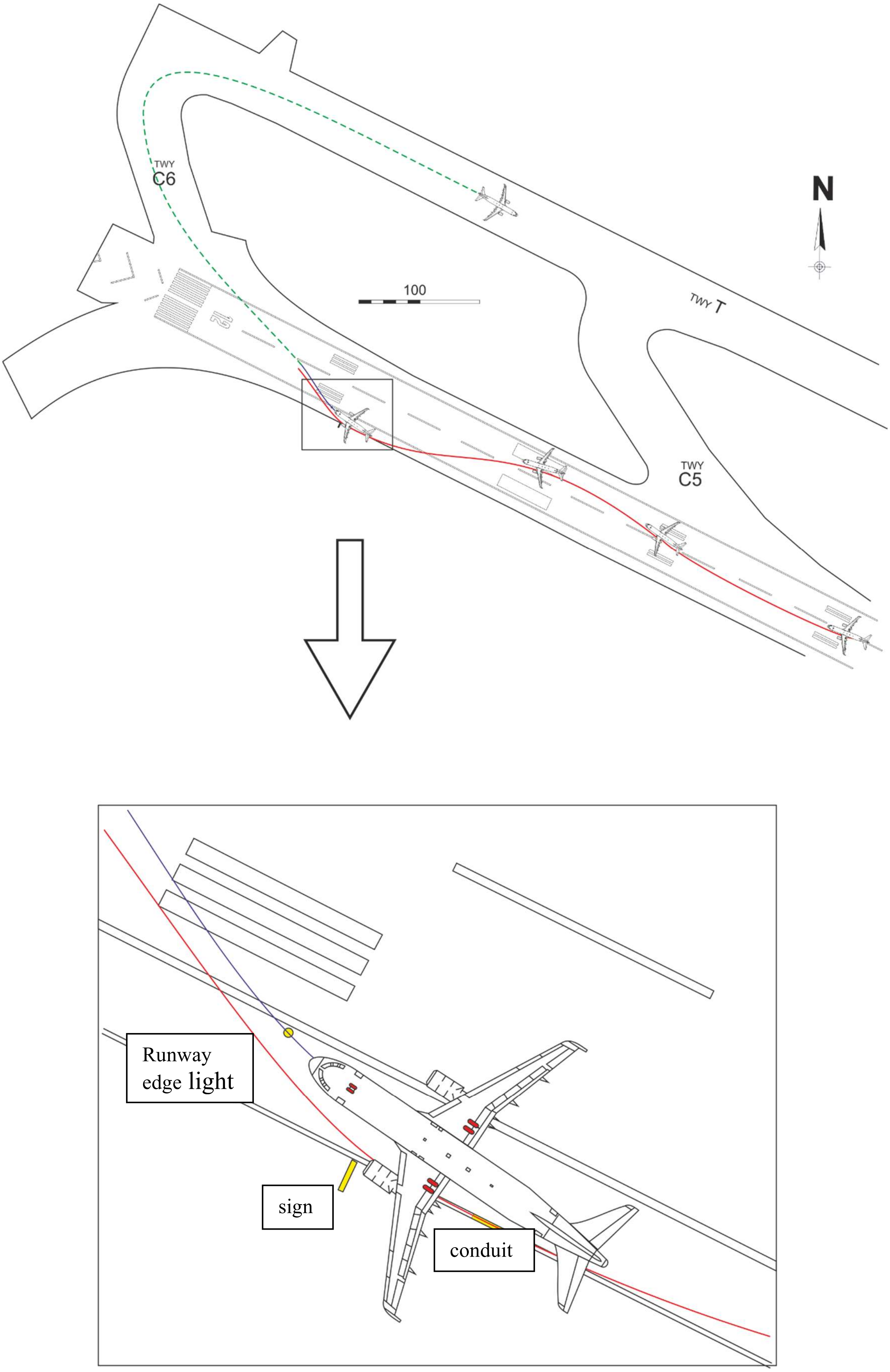


Fig.1.- Diagram of the aircraft's path and location

1.2 Injuries to persons

Injuries	Crew	Passengers	Total in the aircraft	Other
Fatal				
Serious				
Minor				
None	2+4	109	115	
TOTAL	2+4	109	115	

1.3 Damage to aircraft

The aircraft sustained minor damage consisting of dents to the left engine cowling and detached material from one of the nose gear wheels

1.4 Other damage

A runway edge light was broken, a sign indicating the runway exit to a taxiway was pulled out of the ground and broken, and a conduit along the runway edge was broken

1.5 Personnel information

1.5.1 Crew information

The captain, a 43-year old Spanish national, had a JAR-FCL airline transport pilot license (ATPL(A)) with an A320 type rating and an instrument flight (IR) rating, both valid until 31 December 2016. He also had a class-1 medical certificate that was valid until 12 May 2016. On the date of the incident he had a total of 10783:49 flight hours, of which 2943:18 had been on the type

The first officer, a 37-year old Spanish national, had a JAR-FCL airline transport pilot license (ATPL(A)) with an A320 type rating and an instrument flight (IR) rating, both valid until 31 January 2017. He also had a class-1 medical certificate that was valid until 12 March 2017. He had a total of 4955:12 flight hours, of which 1018:12 had been on the type.

On the incident flight, a line flight under supervision was being conducted, such that the duties of the pilot monitoring (PM) were being carried out by a pilot at the airline who was in line for promotion for Captain, and the captain was performing the tasks of the pilot flying (PF).

As for the crew's duty periods, this was the captain's first day flying after two days off duty and 62 h of rest, and the fifth consecutive duty day for the pilot in line for promotion to captain, with morning rotations and a rest period of 14 h since his last duty period.

1.6 Aircraft information

1.6.1 General information

The aircraft, an Airbus A-320-232 with registration EC-MGE and serial number 6607, was manufactured in 2015. It is equipped with two I.A.E. V2527-A5 engines and it has a maximum takeoff weight (MTOW) of 77000 kg and an empty weight (EW) of 42000 kg.

At the time of the incident, the aircraft had 2435:40 flight hours and 1543 cycles. It had a Certificate of Airworthiness issued on 30 September 2015 and an Airworthiness Review Certificate that was valid until 1 June 2016.

Its last maintenance inspection had been an A03 check[2], which had been carried out on 4 February 2016, with 2075 h on the aircraft. This check involves inspections of the aircraft's structures, systems and installations.

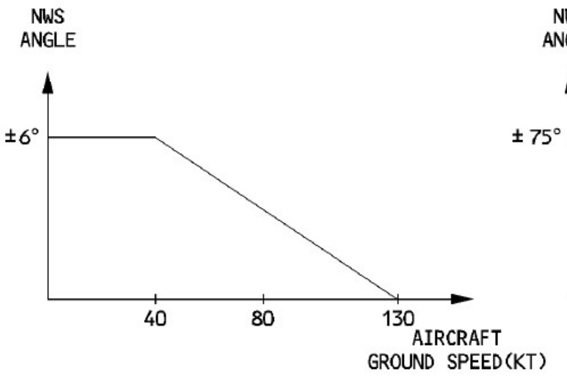
Fig. 2.- Photograph of the aircraft

[2]The A checks are carried out every 750 FH, 121 D or 750 FC (whichever comes first), with the FH generally being the most restrictive. As a result, fewer than 750 FH elapsed between A02 and A03. The A checks have four internal checks that are scheduled sequentially.

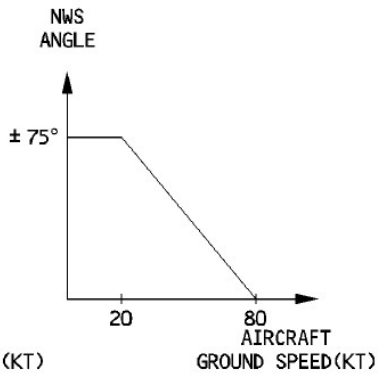
1.6.2 Steering control

The aircraft has nosewheel steering driven by an actuating cylinder that is supplied by the green hydraulic system and electrically controlled by the Braking and Steering Control Unit (BSCU).

The BSCU receives inputs from the rudder pedals, from both pilots' tillers and from the autopilot. The control unit transforms the pilots' steering commands for the nosewheel within the limitations shown in the figures below, depending on the source of said commands and on the ground speed while taxiing



INPUTS FROM STEERING PEDALS



INPUTS FROM STEERING TILLERS

1.6.3 Braking system

The main gear wheels are equipped with carbon multi-disc brakes that can be actuated by either of the two independent braking systems. The normal system uses hydraulic pressure from the green system, while the alternate system is driven by the yellow system with an accumulator back-up.

The anti-skid system provides maximum braking efficiency by keeping the rotational speed of the wheels at the skid limits.

The braking inputs come from each of the braking pedals, actuated by the pilots, or from the automatic braking system, based on the deceleration rate selected by the crew.

1.6.4 Automatic braking system

The aircraft has an automatic braking system that is designed to reduce the braking distance in the event of a rejected takeoff maneuver and to establish and maintain a deceleration rate during landing so as to improve passenger comfort and reduce crew workload.

The system is engaged by pressing the LO, MED or MAX pushbuttons anytime the following conditions exist:

- Green hydraulic pressure available
- Anti-skid electrically powered

- No faults in the braking system
- At least one ADIR-US[3] operational

In order to engage the system, at least two SEC[4] have to be operational.

This system is activated with the command to extend the ground spoilers and is disarmed when the associated pushbutton is pressed, when one or more arming conditions are lost, or sufficient force is applied to one of the pedals when the system is working in LO, MED or MAX modes after takeoff.

1.6.5 Ground spoiler system

The ground spoiler system is designed to reduce lift and increase drag so as to improve braking effectiveness. Spoilers 1 to 5 on each wing act as ground spoilers.

During the landing phase, the ground spoilers will extend as long as:

- The crew has armed them and the throttle levers are retarded to the idle position. The ground spoilers will extend automatically as soon as both main gear legs touch down.

- If the system has not been armed, they will extend as long as, with both main gear legs in contact with the ground, the crew engages the reverser on one engine (with the thrust lever for the other engine in idle).

1.6.6 Reactive windshear alert system

Aircraft EC-MGE is equipped with a reactive windshear warning system that is capable of detecting an actual windshear encounter based on measuring both the vertical and horizontal components of wind speed.

When this situation is detected, an audible "WINDSHEAR" alert is activated and repeated three times. A red signal is also shown on both primary flight displays (PFD) for a minimum of 15 sec with the same indication.

The windshear alert system, associated with the speed reference system (SRS) mode of the flight guidance system, comprises the reactive windshear system (RWS). Both components react immediately to a change in the aircraft's parameters.

[3] ADIRU: Air Data Inertial Reference Unit
[4] SEC: Spoilers Elevator Computer

Fig. 3.- Reactive windshear warning indication on the PFD

1.7 Meteorological information

According to information from Spain's National Weather Agency, the weather situation at the Bilbao Airport at 07:00 UTC on 28 March 2016 was as follows: moderate to strong wind at 30 km/h from the southwest (220º), gusting to a maximum of 50 to 70 km/h, good visibility on the ground, few clouds and a temperature of about 15º, QNH 1011 hPa and a relative humidity of about 50%.

The only significant weather phenomenon present was strong winds from the SW gusting to as much as 70 km/h. There were no significant precipitation events at the time of the incident.

The 07:00 and 06:30 UTC METAR reports indicated wind speeds of 17 and 14 kt from 220º, gusting to 35 and 24 kt, respectively.

METAR/SPECI de LEBB, Bilbao / Sondica (Spain).

SA	28/03/2016 07:00->	METAR LEBB 280700Z 22014G24KT 180V280 9999 FEW070 15/05 Q1011 NOSIG=
SA	28/03/2016 06:30->	METAR LEBB 280630Z 22017G35KT 160V270 9999 FEW070 15/05 Q1010 NOSIG=

The information from the TAF forecast available to the crew when the flight was being planned provided the following information:

FT 27/03/2016 23:00

TAF LEBB 272300Z 2800/2824 22009KT 9999 SCT045

TX19/2815Z TN11/2806Z

TEMPO 2800/2815 22017G30KT

PROB40 TEMPO 2800/2806 22022G43KT

PROB40 TEMPO 2814/2824 32015KT 3000 RA=

This forecast warned of temporary wind conditions involving winds from the SW at 17 kt, gusting up to 30 kt, for the period between 00 and 15, and of a high probability (40%) of winds from the SW at 22 kt, gusting up to 43 kt, between 00 and 06.

According to the airline's criteria for assessing weather forecasts, contained in OM A as part of the flight preparation instructions, for the TEMPO conditions at the estimated time of arrival (± 1 hour) and a persistent meteorological condition, the main wind values have to be at the operational limits, and the gust values are ignored.

The instantaneous readings taken at the two thresholds of the Bilbao Airport were as follows:

FECHA	HORA	VMD2C12	DMD2C12	VMA10C12	RVRMD1C12	VMD2C30	DMD2C30	VMA10C30	RVRMD1C30
28/03/2016	06:50:00	17	190	31	2000	16	210	24	2000
28/03/2016	07:00:00	17	190	35	2000	09	230	23	2000

where VMD is the average of the instantaneous speeds recorded in the 10 previous min, and VMA is the maximum speed of the instantaneous speeds recorded in the 10 previous min.

At 06:00 UTC, a surface wind warning that had been issued the day before expired:

LEBB AD WRNG 1 VALID 272100/280600 SFC WSPD 22KT MAX 43

The graphs of data recorded at the weather station of the Bilbao Airport were also available. This station is at a different location than the threshold sensors. The wind reading obtained directly from the graph indicates that the wind speed was 45 km/h from 220º (see Appendix A).

1.8 Aids to navigation

To help guide the pilot to make contact with the main gear in the touchdown zone, runway 30 at the Bilbao Airport has touchdown zone markings that consist of four pairs of rectangular markings (two set of three and two sets of two) arranged symmetrically around the runway centerline and extending 600 m away from the threshold. Since the second pair of three bars coincide with the aiming point marking, only the latter is indicated in the PAPI.

Also indicated, though not as prominently, are two pairs of rectangular markings with one bar that extend a further 300 m.

Figure 4. Photograph 1 TDZ marking, runway 30, on date of incident

In addition, the runway lighting system includes the touchdown zone lights, which extend over 900 m.

1.9 Communications

The investigation had access to recordings of the communications between the aircraft and air traffic control services, as well as to the recordings of the communications contained in the CVR.

During the incident, the crew were in contact with Bilbao Approach (APP) on 127.45 MHz and with the control tower on 118.50 MHz

The communications worked correctly. A description of the most relevant communications is provided in Section 1.11, Flight recorders.

1.10 Aerodrome information

The Bilbao Airport (LEBB) is located 12 km northeast of the city of Bilbao at an elevation of 41 m/136 ft. The airport has two runways in a 12/30 orientation that are 2600 and 1910 m long, respectively, and 45 m wide.

As concerns runway 12/30, the runway 30 threshold is at a higher elevation than the 12 threshold. There are two rapid exit taxiways (C5, C6) to exit runway 30 and access the

The Bilbao Airport has been certified as per Regulation (EC) No 216/2008 (Basic Regulation) and Regulation (EU) No 139/2014 since 26 November 2015. The Certification Specifications and Guidance Material for Aerodromes Design (CS-ADR-DSN Issue 2, 29/01/2015) are applicable to the airport.

According to these specifications, on the date of the incident, runway 30 (LDA[5] of 2140 m) should have had its TDZ indicated with four distance-coded markings consisting of four pairs of markings extending 600 m away from the threshold, separated by 150 m between them (only three are present, since the second coincides with the aiming point marking), concluding with two pairs of markings with a single line each to provide intuitive information on the length of the TDZ, the LDA and the distance between thresholds.

Figure 5. Photograph 2 Current TDZ markings on runway 30.

Initially, runway 30 had one indication for the touchdown zone consisting of six pairs of markings separated by 150 m between them and extending along 900 m from the threshold (only five were visible, since the second coincided with the aiming point marking).

[5] LDA Landing distance available

Figure 6. Photograph 3 TDZ markings, runway 30, before the date of the incident

According to information provided by AENA, in August 2012, work was done to adapt the horizontal markings by using pressurized water to change from 3-2-2-1-1 to a 3-2-2 configuration. The transition from a 3-2-2 to a 2-2-1 configuration took place in November 2016, and relied on pressurized water to clean the six outside lateral stripes on the first pair and then repainting them, and the four erased in 2012, with a gray patina to remove any doubt with respect to the contrast between the clean aggregate and the asphalt.

The data sheet for the Bilbao Airport in the airline's Operations Manual C (Rev. 03 of 18 February 2016) shows a photograph of the runway 30 threshold that contains a 900-m TDZ marking that was not present on that date.

As concerns the runway lighting system, it includes the touchdown zone lights, which did not undergo any changes and which extend for 900 m, as required.

The data from the friction coefficient readings taken on 26 March and 2 April 2016 (immediately before and after the date of the incident) were satisfactory.

1.11 Flight recorders

1.11.1 General information

The aircraft was equipped with a Honeywell HFR-5D flight data recorder (FDR), with serial number 03709, and a Honeywell HFR-5V cockpit voice recorder (CVR), with serial number 03473.

The data from both were downloaded at a laboratory external to the CIAIAC[6].

[6] CIAIAC Civil Aviation Accident and Incident Investigation Commission

1.11.2 Flight data recorder (FDR)

An analysis of the data contained in the FDR yielded the following conclusions:

Initial approach and go-around maneuver

At 06:15:07, the aircraft cleared 6000 ft, reaching point SARRA (IAF) to make the ILS Z approach to runway 30 at the Bilbao Airport. To make this maneuver, the crew configured the aircraft with 22º of slats and 20º of flaps (CONF 3), passing through 3963 ft at a calibrated airspeed (CAS) of 157 kt. The wind recorded by the FMS during the approach was from the west-southwest at a variable speed that reached maximum values of 41 kt.

At 06:21:17, at 800 ft AGL, the recorded wind varied over six seconds from 213º at 43 kt to 189º at 25 kt. This sudden change in speed and direction triggered the activation of the reactive windshear warning for two seconds, as a result of which the crew conducted a go-around maneuver. At that point they were at a radioaltitude of 684 ft and 2 NM away from the runway threshold.

The graph in Appendix C shows this change in the wind along with the activation of the windshear reactive warning.

The aircraft remained on the runway heading, climbing initially to 6000 ft. The gear retraction was completed at an altitude of 1727 ft, at the same time as the crew reduced thrust for the first time. The incremental retraction of the flaps/slats to a clean configuration (CONF 0) was started at 2731 ft.

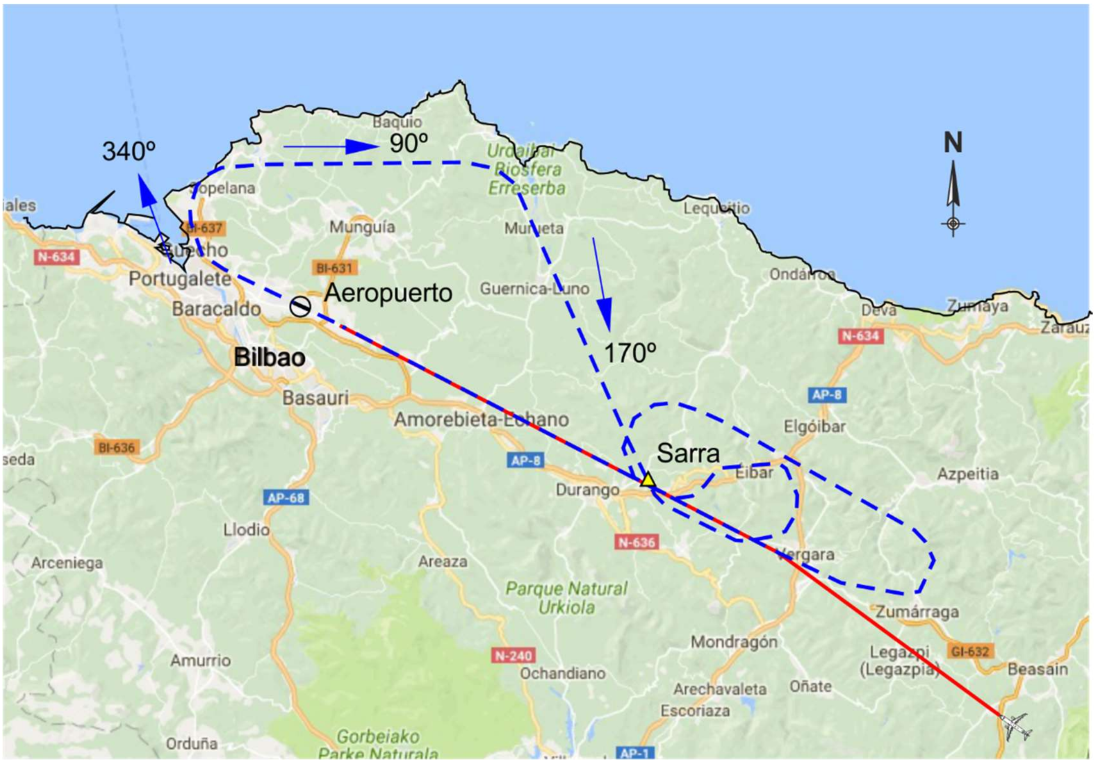


Fig. 7.- Flight path taken by the aircraft

At 06:23:41, the crew began a turn, first to 340º and then to 090º. They continued to climb to FL080 and accelerated to a calibrated airspeed (CAS) of 250 kt.

At 06:27:26, they turned to 170º direct to point SARRA to enter the holding pattern, holding at FL080. At 06:31:26, the crew started the hold maneuver, flying a complete circle, which they completed at 06:45:08, after which they began the second approach. During the outbound leg of the pattern they descended to 6000 ft.

At 06:50:39, they reached a radioaltitude of 1000 ft. The aircraft was configured with 22º of slats and 20º of flaps (CONF 3), the landing gear down and established on the glide slope and localizer with a descent rate of 976 ft/min and a CAS of 150 kt (Vapp[7] + 9). Both autopilots were engaged, as was the auto-thrust system. The ground spoilers were armed and the autobrake was set to the MED position.

The wind during the final approach segment was steady from the west-southwest, gusting up to 40 knots. The drift angle ranged between 7º and 13º left of the QFU[8] (298º).

[7] Vapp: Target speed. Corresponds to the minimum selectable speed plus corrections. In the FDR, it is recorded under the APPCAST parameter. For the first approach it was 136 kt, and for the second one it was 141 kt.

[8] QFU Q-code that indicates the runway's magnetic heading.

Disconnection of AP1 and AP2

At 06:51:20, while crossing through a radio altitude of 384 ft, the crew disengaged both autopilots and inputs were made to the CM2's[9] side stick.

From then on, the FDR shows that the aircraft followed the ILS localizer and glide slope, which required the crew to make inputs to the side stick that resulted in changes to the descent rate and roll angle. The drift angle ranged between 5 and 10º left of the QFU (298º).

After 06:51:21, descending through a radio altitude of 346 ft, the value of the CAS rose above Vapp+10 for 12 seconds, reaching an instantaneous value of 158 kt (Vapp+17).

Flare maneuver

At 06:51:40, while descending through a radio altitude of 60 ft, the crew initiated the flare maneuver, reducing the descent rate. The instantaneous wind component was from 208º at 16 kt. The CAS was 144 kt, which increased to an indicated airspeed (IAS[10]) of 150 kt (Vapp + 9) during the execution of the maneuver.

For the flare maneuver, the crew pulled back completely on the side stick to increase the pitch angle, followed by quick forward motions of the stick to the midpoint of its travel. Laterally, they used inputs that spanned almost the entire range of stick travel from left to right. No significant inputs to the rudder pedals were recorded. The thrust levers were pulled back to the idle position.

The drift angle ranged between 3 and 7º left of the QFU (298º).

Appendix D provides a graphic representation of the various parameters analyzed.

[9] CM Crew member. CM1 is in the LH seat and CM2 in the RH seat.

[10] The speed recorded in the FDR is the CAS, which is very similar to the IAS. When the aircraft is in the ground effect, this relationship is altered, as reflected in the AFM (Figure 8), due to the aircraft's landing configuration.

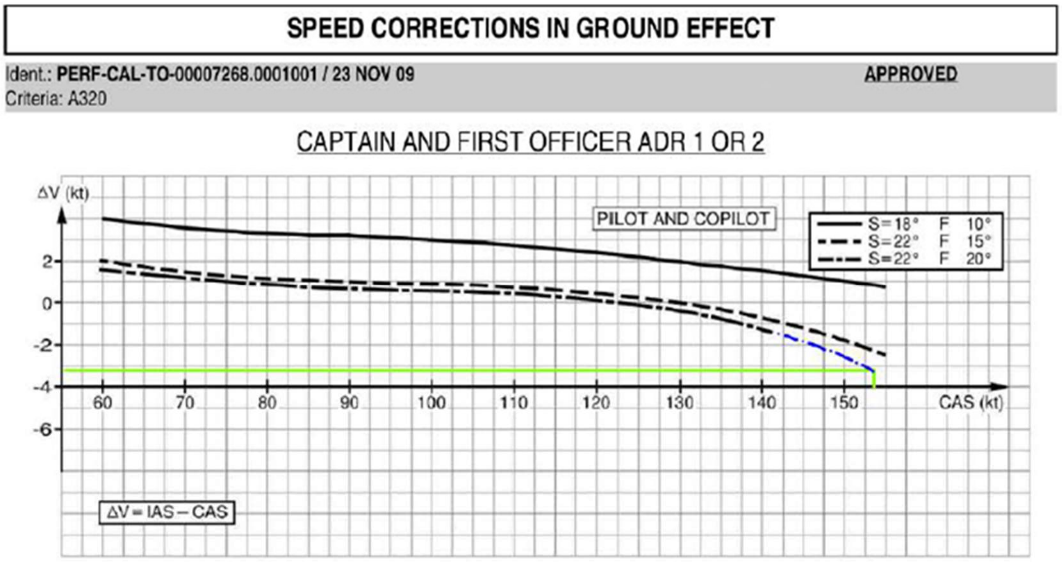


Fig. 8.- Relationship between IAS and CAS in ground effect (Airbus AFM)

Touchdown

Both main landing gear legs touched down simultaneously at 06:51:52 in the center of the runway, 740 m away from the threshold at a CAS of 141 kt on a heading of 294º, 4º left of the runway centerline heading. The ground spoilers deployed at that time. The nosewheel contacted the runway 2 seconds later, at 132 kt on a heading of 299º. The acceleration values recorded were 1.083 G vertically and 0.195 G laterally. The ground spoilers deployed fully and the autobrake (MED) engaged.

At 06:51:56, with the aircraft on the runway centerline, the FDR showed that the reversers were deployed and large inputs were made to adjust the pitch, and more moderate inputs were made to control the roll. From the moment of touchdown, the crew made small corrections to the right using the rudder pedals.

Initial deviation (segment 1)

At 06:51:58, with a ground speed (GS) of 119 kt, the FDR recorded a deviation to the left of the runway centerline to a heading of 291 (QFU-7º). For approximately 4 seconds, the aircraft’s course was corrected until it reached 301º (QFU+3º), returning toward the center of the runway. A lateral acceleration of +0.172 G was recorded.

The ground speed when the deviation started was 119 kt. The crew increased the deflection of the right rudder pedal to its maximum value. Simultaneously, at 06:52:00, the crew made an input to the right brake pedal that disengaged the autobrake system, at the same time as the reversers were stowed.

The FDR data showed that the values for the brake pedal inputs did not correlate to an increase in brake pressure in the corresponding wheels. The manufacturer verified that the wheel speed parameter did not show any activity by the anti-skid system, and that the difference between the brake pressure parameters could be explained by the FDR sample rate, which is of 1 datapoint every 4 seconds, alternating between the brake pressure for the wheels on that side. The pedal deflection was therefore too short in duration to be evident in the brake pressure parameter.

As concerns the reverse thrust, the FDR showed, by means of the thrust lever angle (TLA[11]) parameter, a reduction in reverse thrust to the IDLE REV position. This lever position caused the parameter for the full deployed (FULDEP) signal to indicate an instantaneous stowing of the reversers on both engines at 06:52:01. This was followed by a full deployment signal for the right reverser (FULDEP2) [12]. The signals remained asymmetric for 6 s, when the full deployment of the left engine was recorded. According to the FDR data, no significant differential increases were recorded in engine power during that interval.

The FDR recorded inputs to the right pedal, which reached its maximum deflection.

No crew actions were recorded prior to this deviation that could have caused it.

<u>Second deviation</u> (segment 2)

As a result of the corrections made, between 06:52:02 and 06:52:05, the aircraft's heading took on positive values with respect to the QFU (298º) ranging from 301º to 310º, causing it to move to the right side of the runway.

During this maneuver the aircraft experienced a lateral acceleration of 0.297 G.

During this interval, the side stick was moved to the right and the pedal input shifted from full right to full left. The right differential braking that had been applied in the previous segment was also completely stopped.

The roll angle ranged from 2º left to 2º right.

<u>Third deviation</u> (segment 3)

Between 06:52:05 and 06:52:11, the aircraft's heading reduced its value until it reached negative values with respect to the QFU (298º), between 275º and 292º, causing it to move toward the left side of the runway. At the time when the course trend reversed, the ground speed (GS) was 80 kt.

During this maneuver the aircraft sustained maximum longitudinal and lateral accelerations of 1.161 G and 0.543 G, respectively.

The pilot applied full left side stick, gradually reduced the deflection of the left rudder pedal and started to apply significant right pedal. He also applied right differential braking after 3 seconds.

[11] TLA Thrust Lever Angle.
[12] FULDEP2 Full Deployed 2.

The FDR also recorded the deployment of both reversers once more.

The roll angle varied between 2º right and 4º left.

Fourth deviation (segment 4)

Between 06:52:11 and 06:52:25, the aircraft's heading again changed to the right side of the runway (from 292º to 324º). When the aircraft turned right, its GS was 50 kt, which was lowered to 8 kt so the aircraft could clear the runway and taxi.

The lateral and vertical acceleration values were 0.50 G and 1.043 G, respectively.

The pilot applied full right side stick, shifted the rudder pedal input from right to left and gradually reduced the previous right differential braking.

The roll angle reached a value of 4º left.

The reverse thrust reached its maximum value.

Starting at 06:52:18, the pilot applied symmetric braking to stop the airplane, with a GS of 30 kt on a heading of 322º. At that point, idle reverse thrust was applied. The reversers were stowed with the airplane under control at 8 kt.

Appendix E contains a graph of the braking parameters, the user of reversers and the inputs to the side stick.

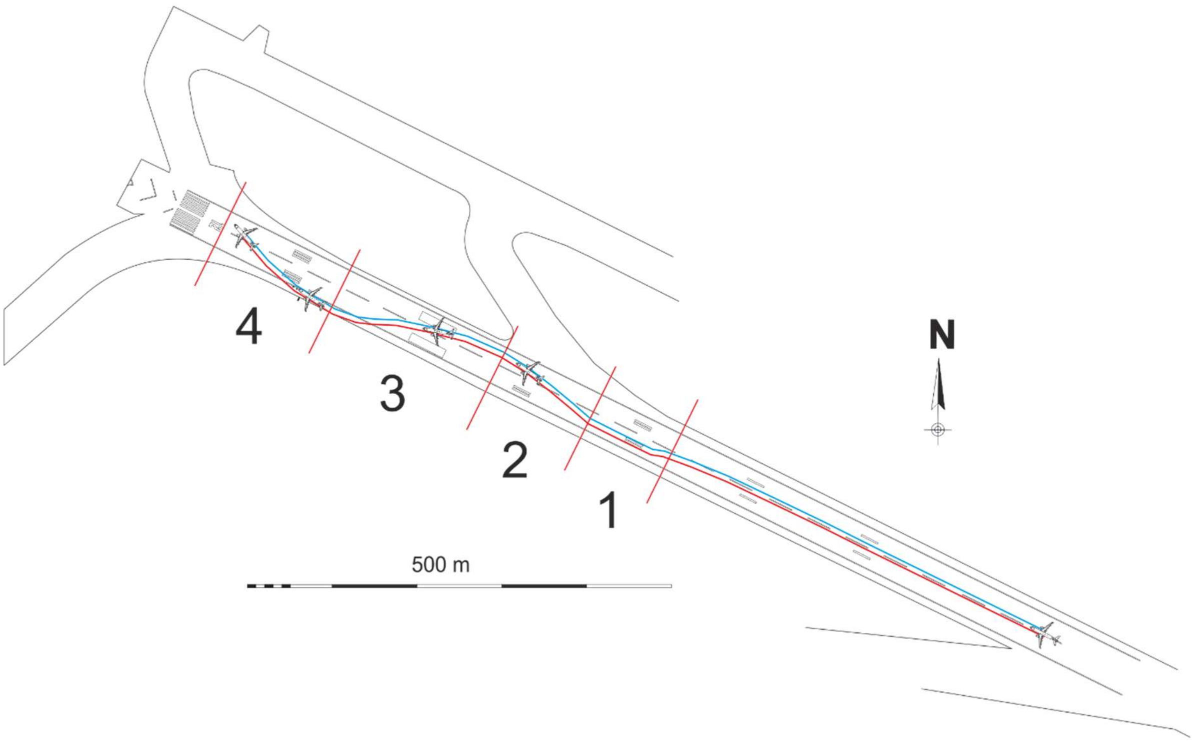


Fig. 9.- Segments of the aircraft's path on the runway

Readings from the angle of attack (AOA) sensors

While the aircraft was veering, there was a variation in the readings from the angle of attack sensors located on either side of the fuselage.

When the first deviation occurred, there was a sudden difference between the readings from the left-side sensor (AOA1) and the right-side sensor (AOA2). This indication is consistent with a wind gust whose relative west-southwest component led to an increase in the angle of attack reading on the left side of the aircraft.

The graph in Appendix F reveals a second variation, but after the second deviation to the left, meaning said deviation cannot be attributed to the presence of a gust at that time.

The wind values recorded by the FDR are not valid once the aircraft is on the ground.

1.11.3 Cockpit voice recorder (CVR)

The cockpit conversations recorded reveal that the crew were engaged in a captain checkout flight for the first officer, with the instructor, who was seated in the RH seat (CM2), acting as the pilot flying.

During the course of the flight, the CVR recorded various tips and instructions that the PF gave for the operation of the flight, including the contingency of having to execute more than one go-around. They held the approach briefing at 06:02:49, noting a potential issue with the wind on approach. They carried out an initial ILS Z approach following the instructions they were receiving from ATS. At 06:05:24, the contacted Bilbao Approach for the first time, receiving wind information for the runway, which was from 210º at 20 kt gusting to 35 kt. They were also informed that preceding aircraft had encountered moderate turbulence on approach, with the wind peaking at 40 kt with a 5 kt tailwind component on final. In light of this information, the crew inquired if any traffic had executed a go-around, receiving a negative response. The crew then reviewed the go-around procedures and conditions, as well as the restrictions on reverser use in the event of a crosswind landing.

They contacted the control tower at 06:15:39, which gave them wind information for the runway (200º at 14 kt, gusting to 29 kt). The instructor (PF) mentioned the good practice of landing with the feet on the brake pedals to aid the steering effect of the rudder through differential braking.

The crew discussed setting a Vapp of 136 ft.

During the approach, the pilot continued to ask ATC for wind information. ATC replied that the wind was from 240º at 16 kt. Upon hearing this information, the pilot flying asked about the speed of the gusts, to which the pilot monitoring replied that ATC had not provided that information. The PF then instructed the PM to ask, to which ATC replied that the wind was gusting at 30 kt. The instructor (PF) then made a comment to note that ATC did not usually provide information they deemed to be irrelevant.

One minute and 20 seconds after this conversation, the CVR recorded the aural windshear warning (synthetic voice), which was repeated three times.

The crew reacted by executing a go-around, which they reported to ATC a minute later. ATC cleared them to fly the standard maneuver and instructed then to report their intentions. The crew stated they were continuing with the standard missed approach maneuver and that they would call back. The PF asked the PM to inform ATC that they had gone around due to wind gusts.

The crew then noted that the situation did not seem to warrant the windshear warning. Once the aircraft was level, an announcement was made to the passengers informing them that they had executed a go-around due to windshear and that they planned to make another approach.

While en route to point SARRA and in the holding pattern, the crew considered their fuel remaining and monitored the progress of another Vueling flight (VLG2608), which was making the ILS approach to runway 30. Following the successful landing of VLG2608, and since no other aircraft were going around, they decided to make another attempt.

During the second approach, they were told of the wind present on the runway (240º at 17 kt) and of the presence of 24-kt gusts on the 12 threshold and up to 30 kt on the 30 threshold. The crew discussed increasing the Vapp to 141 kt. During the landing, the tower provided updated information on the wind situation: 240º 20 kt, 240º 15 kt, 230º 11 kt, and 220º 16 kt.

After touching down, the pilot monitoring said “Give it right foot”. The CVR also recorded the noise of the impact against the sign, subsequently confirmed by the pilot monitoring when he said, “We hit a sign”.

Once the landing was under control, they reported the incident to the control tower, where the controllers were aware of the event, having seen the maneuver.

They exited the runway via taxiway C6, and ATC instructed them to go to C5 so the Firefighting Service could inspect the airplane and the brakes.

Once they were taxiing toward C5, they asked the tower about the wind over the last 5 minutes. The crew informed the tower that in the final third of the runway, while at 100 kt and already braking, they had been affected by a wind gust.

The tower informed them that there were differences between the wind gauges at the thresholds and that having landed long could have affected them, noting that the readings from the wind gauges installed on the two thresholds (12/30) differed by about 10 to 15 kt.

1.12 Wreckage and impact information

As a result of its runway excursion, the aircraft sustained damage to its left engine cowling, and loss of material from a tire on the nosewheel landing gear.

Fig. 10.- Damage to the aircraft

In addition, as the aircraft traveled on the runway, it broke a runway edge light, a sign indicating the exit to a taxiway and part of a conduit on the runway strip.

Fig. 11.- Damage to the airport

1.13 Medical and pathological information

N/A

1.14 Fire

There was no fire during the incident.

1.15 Survival aspects

There was no emergency evacuation. The passengers were disembarked without incident.

1.16 Tests and research

1.16.1 Statement from the crew

The contents of the statements given by the crew are provided below.

With respect to planning:

In light of the weather forecast calling for windshear at the Bilbao Airport, we decided to take on 800 kg of extra fuel so as to be able to make an additional approach and return to Barcelona in the event of a second go-around. We decided that the captain would be the pilot flying (PF).

With respect to the approach preparation:

As per the OM-C airport briefing[13], the medium autobrake setting was selected. Due to the potential windshear situation, we decided to do the landing distance calculation with flaps 3 and a margin of up to +15 kt over VLS (with A/THR and 10 kt for additional margin), yielding a FOLD[14] (Factored Operational Landing Distance) of more than 400 m below the LDA (Landing Distance Available). To be more conservative, the reduction in the FOLD due to the use of reversers was not considered, but we left open the option of using them depending on the wind conditions present during the landing. We did an additional briefing to go over the windshear and go-around procedure.

First approach:

Before the glide slope we were configured with Flaps 2 at 6000 ft from SARRA, and fully stabilized earlier than required. The landing list was complete before 2000 ft TDZE (Touchdown Zone Elevation) and we were focused solely on the approach and the wind. We asked the tower for wind and gust readings on several occasions, since they were only giving us wind but not gust information. The wind speeds were always within the limits. After crossing 1000 ft TDZE, still stabilized, the reactive windshear alarmed and we carried out the maneuver, with the autopilot engaged, followed by the go-around maneuver. During the approach we only felt slight turbulence.

Go-around:

We flew the published procedure and at 6000 ft were cleared to fly direct to SARRA, climbing to FL 080, and we entered a holding pattern. We informed ATC that we would report our intentions to start another approach after evaluating the outcome of another Vueling aircraft on approach. Following its successful landing, we decided to commence another approach.

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[13] Briefing: brief work meeting that crews hold before starting a flight or a flight rotation, intended to result in, on the one hand, **a safer and more efficient operation**, and on the other, **to facilitate the integration and cohesion of the crew as a work team**.

[14] FOLD Factored operational landing distance

Second approach:

It was very similar to the first, but with slightly lower wind speed values from the tower. We kept the autopilot engaged until about 200 ft above the approach minimums. We were not aware of any significant deviations in the flight parameters that could not be recovered with small corrections, in keeping with the standard operating procedures.

Landing run:

The landing seemed normal, with both feet well situated on the pedals, anticipating a crosswind and gusts. The airplane touched down on the centerline at the end of the TDZ. The medium autobrake activated, as preset, and the reversers were selected to maximum. Everything was normal, and the rate of deceleration should have allowed us to clear the runway via C5. Seconds later the first sudden turn of about 20º into the wind (left) occurred. We used the rudder pedals and the reverser thrust was reduced to idle. This improved the situation but it was not enough to control our direction, even with maximum deflection of the rudder pedal, so we had to apply differential braking to return to the runway centerline, at which point the medium autobrake disengaged. Once we regained the centerline, we started to brake with both feet, attempting to maintain steering control. At that point a second turn into the wind occurred that was more pronounced than the first, forcing us to again apply maximum rudder pedal. This being insufficient, we had to apply the brake on the same pedal to keep from running off the edge of the runway. The aircraft impacted a sign informing of the next taxiway (C6) to the left. The impact was likely with wheel 1 on the main landing gear.

From that moment on, the control of the aircraft was good and control was transferred to CM1 at a normal taxi speed.

Exiting the runway and taxi to parking:

We exited the runway via C6, engaged the brake fan and remained in position until we were able to contact the tower. We heard the firefighters being dispatched on the radio, and we received confirmation that we had contacted a light and sign on the edge of the runway, so we requested that we be checked for damage. The tower asked us to taxi close to C5, where the firefighters conducted an inspection of the brakes. We asked the tower for wind and gust information for threshold 12 for our landing time, and the tower said there might have been a 10 to 15 kt difference with respect to threshold 30. We were escorted by the firefighting service to parking, where we stopped the engines and disembarked the passengers normally. We conducted an external inspection of the aircraft and entered the damage into the technical log. We also visited the runway to take photos of it and of the affected edge.

The crew underscored the following aspects:

Concerning the distance calculation:

We calculated the operational distance before the descent on purpose so as to accurately determine the limit for the worst possible acceptable conditions under which the landing could be carried out, even those conditions we might be informed of at the last second, so that we could decide whether to land or go around and return to Barcelona.

Specifically, by increasing Vapp for safety reasons due to gusts (due to flaps 3, use of the A/THR and due to gusts), in keeping with the technical recommendations from Airbus and in our Operations Manual, the flare could have been affected, and we considered the additional margin of 300 meters still present to offset variable wind gusts, even a tailwind, that could affect us during this phase.

And so, performance-wise, for this specific flight, our limit point for contacting the runway was 900 meters away from the threshold, within the operational limit. Our intention was to land as early as possible, but in practice, the increased calculated airspeed and the gusts did not allow us to achieve the proper attitude to land safely earlier. During those seconds of the maneuver, we were very mindful not to force a touchdown with the nose gear or a three-point landing.

Beyond that limit point at the end of the TDZ, we would have gone around without hesitation, but we touched down exactly at that limit point calculated as acceptable. Bilbao actually has six visible TDZ markings that indicate the 900-meter distance. The last two are a little faded but they are perfectly identifiable. These marks provided a visual cue to make the decision, considering the remaining minimum runway required (including the additional legal safety margins).

Concerning the corrective actions:

Once the crew sensed the first yaw resulting from the weathercock effect, the airplane started to skid, initially maintaining its movement along the runway centerline. The pilot reacted by dropping the right wing as the course changed, until the airplane was clearly heading off the runway. The deflection of the rudder to the right and the stowing of the reversers alleviated the situation, but the airplane continued heading off the runway.

According to the pilot's statement, the decision to also apply right differential braking came later, when they thought it was absolutely necessary to avoid going off the runway and considering the circumstances and the wind present at that time. Had he not had both feet over the top of the pedals so as to be able to apply the brake to the rudder pedal that was already depressed, the airplane would have undoubtedly gone off the runway at high speed during that initial yaw, since having to stop applying the brake in order to raise his foot to brake would have been critical.

It should be noted that once the initial yaw was corrected, the control was complicated by the constantly changing conditions (winds and gusts that came and went, oscillation of the wings, which noticeably affected the weight on the main wheels and their braking ability). A gust that disappeared meant that a correction was no longer necessary. The skid also made the wings sway, resulting in effects that helped or hindered the braking action. Even without changing the pressure on the brakes, their effectiveness differed due to all this and the pilots had to adapt to the changing circumstances and forces to maintain directional control.

Bearing in mind that the weathercock effect on the ground in the A320 requires not correcting with the downwind wing, the pilot reasoned that the movement of the side stick that is seen in the FDM must have been the inputs he made to offset the oscillations of the wings, which hampered control and braking accuracy, his only goal being to keep the wings level to "*achieve stability and control*".

In both the first and second yaw events, the pilot was concerned because an imbalance during the skidding could make a wing touch the ground. Occasionally the braking input had to be reduced a little to regain stability. The downward vertical movement sought to maintain contact between the gear and the asphalt and the braking effectiveness.

The pilot felt that he was providing the inputs that were required at all times, though there was inertia to consider and the wind changes were unpredictable, which affected the ultimate ability to control the airplane.

1.16.2 Post-flight report

The aircraft manufacturer stated that the PFR[15] did not record any system failure that could have been involved in the incident.

At 06:52, the report contains an ELAC[16]1-COM OR BUS3 FROM ADR3 fault message. This fault is associated with the monitoring of the ADR[17] parameters by the ELAC1. The most likely explanation is that the fault message was issued due to a discrepancy in the calibrated airspeed (CAS3) values during the landing run.

1.17 Organizational and management information

The airline's Operations Manuals describe various aspects involving the operation of the incident aircraft.

1.17.1 Descent

Operations Manual B (point 2.1.12.6.2 Descent preparation) states:

"The PF verifies FOLD<LDA, considering the condition of the runway, airplane configuration and type of braking (i.e. A/BRAKE (LO, ME), REV MAX/IDLE, MANUAL BRAKING),

Factored Landing Distance = In-flight Landing Distance x 1.15

In special (emergency) circumstances the crew can ignore this margin.

The result of the FOLD will be entered in the OFP."

In keeping with these requirements, the crew calculated the FOLD using the data for the aircraft characteristics contained in the QRH[18].

The crew based their calculations on a landing in a flaps/slats CONF 3, dry runway (DRY) and MED autobrake.

[15] PFR Post Flight Report.
[16] ELAC Elevator and Aileron Computer.
[17] ADR Air Data Reference.
[18] QRH Quick reference handbook.

The result, corrected for the landing weight and speed, factored at 15%, was 1760 m, which yielded a margin of 380 m with respect to the published LDA for runway 30 at LEBB of 2140 m.

As for the target speed calculation, the crew used a reference VLS[19] corresponding to a weight of 58 tons, which was 131 kt[20]. The crew applied a correction due to making the approach with autothrust (A/THR ON).

The operator's QRH includes a note stating that "in the event of operations in a strong or gusty crosswind in excess of 20 kt, the Vapp must be at least VLS + 5 kt. The 5-kt increase over the VLS can be raised up to 15 kt at the flight crew's discretion."

In light of the above information, in the end the crew decided to apply a 10-kt correction, which resulted in a target Vapp of 141 kt.

vueling A319/A320/A321 QUICK REFERENCE HANDBOOK	IN FLIGHT PERFORMANCE	PER-D 9/10 09 JAN 17

LANDING DISTANCE WITHOUT FAILURE

Ident.: PER-D-00014077.0005001 / 28 FEB 14
Applicable to: EC-LQJ, EC-LQK, EC-LQL, EC-LQM, EC-LQN, EC-LQZ, EC-LRA, EC-LRE, EC-LRM, EC-LRY, EC-LUN, EC-LUO, EC-LVS, EC-LVT, EC-LVV, EC-LZF, EC-LZM, EC-MBS, EC-MBT, EC-MDZ, EC-MEA, EC-MEL, EC-MEQ, EC-MER, EC-MES, EC-MFK, EC-MFL, EC-MFM, EC-MFN, EC-MGE, EC-MJB, EC-MJC, EC-MKM, EC-MKN, EC-MKO, EC-MLE, EC-MNZ, EC-MOG

The Reference Distance (REF DIST) considers : Sea Level (SL), ISA, no wind, no slope, no engine reverse thrust, manual landing(1), VAPP=VLS without APPR COR.

6 - DRY										
Corrections on Landing Distance (m)			WGT(2)	SPD	ALT	WIND	TEMP	SLOPE	REV	OVW
Braking Mode	LDG CONF	REF DIST (m) for 66T	Per 1T above 66T	Per 5kt	Per 1000ft above SL	Per 5kt TW	Per 10°C above ISA	Per 1% Down Slope	Per Thrust Reverser Operative	If OVW PROC applied
Maximum MANUAL	FULL	1 080	+ 40	+ 60	+ 40	+ 130	+ 30	+ 20	- 20	+ 760
	3	1 130	+ 50	+ 80	+ 50	+ 120	+ 40	+ 20	- 20	+ 990
AUTOBRAKE MED	FULL	1 360	+ 30	+ 90	+ 50	+ 130	+ 40	+ 10	0	+ 230
	3	1 420	+ 40	+ 100	+ 50	+ 140	+ 50	+ 10	0	+ 250
AUTOBRAKE LOW	FULL	[illegible]	+ 50	+ 130	+ 80	+ 200	+ 60	+ 20	- 10	+ 260
	3	2 030	+ 50	+ 150	+ 80	+ 210	+ 70	+ 30	- 10	+ 290

(1) Automatic Landing correction: if CONF FULL, add 190m. If CONF 3, add 260m.
(2) Weight correction: subtract 10m per 1T below 66T.

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[19] VLS: Minimum selectable speed
[20] QRH PER-C 7/14 de 09/01/17

1.17.2 Landing configuration

OM-B, point 2.1.12.12 on "Normal landing" states that "if allowed by the FOLD, the landing should be made with Flaps 3, Autobrake LOW and IDEL REV, only if there is no degradation of the landing distance (e.g. weather, braking action, failures, etc.)."

The AUTOBRAKE should be used (LOW or MED if necessary) to ensure symmetric and regular braking for passenger comfort.

The FCOM[21] 3 (Standard Operating Procedures – Descent Preparation) provides the following information: "CONF 3 should be considered depending on the runway length available and the performance required for the go-around maneuver, or if considering the possibility of encountering windshear or severe turbulence during the approach."

In the Supplementary Techniques – Adverse Weather section of FCOM 3, it also states to do the approach in slats/flaps CONF 3 as a precaution if windshear conditions are expected.

In addition, the FCTM[22] (Supplementary Information – Adverse Weather) reiterates the advantage of considering a landing in CONF 3 if windshear is expected during the approach.

However, in the operator's operational briefing on airport LEBB (from 11/04/2016 REV: 0), the section on Landing Considerations strongly recommends the use of the FULL flaps configuration and MEDIUM AUTOBRAKE.

The crew flew both approaches in CONF 3 and MEDIUM AUTOBRAKE.

1.17.3 **Stabilization criteria**

The stabilized approach criteria are laid out in FCOM 3 "Standard Operating Procedures".

The goal is to be stabilized on the final glide slope at Vapp speed and in the landing configuration 1000 ft above airport elevation in instrument meteorological conditions or at 500 ft above airport elevation in visual meteorological conditions, after a constant deceleration in the glide slope.

For an approach to be stabilized, all of the conditions below must be met at or before the stabilization height:

- The aircraft is on the correct lateral and vertical flight path planned.
- The aircraft is in the desired landing configuration.
- The thrust is stabilized, normally above idle, to maintain the target approach speed throughout the desired glide slope.
- There are no excessive deviations in flight parameters.
- The target speed is maintained between -5 kt and +10 kt.
- The pitch angle is not below -2.5º or above +10º.
- The roll angle does not exceed 7º.
- The sink rate is below 1000 ft/min.
- The localizer (LOC) and glide slope (G/S) deviations are within one dot.

[21] FCOM : Flight Crew Operating Manual
[22] FCTM: Flight Crew Training Manual

If the aircraft is not stabilized on the approach flight path at 1000 ft above airport elevation in instrument meteorological conditions or at 500 ft above airport elevation in visual meteorological conditions, a go-around maneuver must be executed.

The FCOM (PRO-NOR-SOP-18-A P4/6) also provides the following information:

For an approach to be considered stabilized, the following conditions must be satisfied at or before the stabilization height:

- The aircraft is in the correct lateral and vertical flight paths.
- The aircraft is in the desired landing configuration.
- The thrust is stable, normally above idle, and the aircraft is at the target speed for the approach.
- The crew does not detect any excessive deviations in the flight parameters.

If any of these conditions is not satisfied, the crew must execute a go around unless only minor corrections are required to recover stabilized approach conditions.

1.17.4 Considerations specific to the approach to the Bilbao Airport

The operator's operational briefing on airport LEBB (from 11/04/2016 REV: 0) contains considerations for crews to bear in mind during the approach maneuver, stating that:

"When the wind is coming from the directions between 160º and 270º at a speed of 20 kt or more, and there are no favorable pilot reports (PIREPS), expect moderate turbulence on final. Be prepared to execute a go-around and divert in this situation.

Do not initiate the approach and/or continue beyond the IAF when the wind speed on the ground is at or above 40 kt (including gusts) and its direction is between 160º and 270º."

1.17.5 Go-around

The operator's OM-B (point 2.2.12.14) states that "the PF[23] must initiate the published go-around procedure whenever... d) the airplane will not land within the TDZ (300 m before to 600 m after the TDZ)."

1.17.6 Landing technique

1.17.6.1 Disengaging the autopilot

The FCTM, in the Normal Operations – General Approach section, specifies that "the pilot must disengage the autopilot early enough to take manual control of the aircraft and evaluate the drift before the flare. In crosswind situations, the pilot must avoid any tendency to drift in the downwind direction."

[23] PF: Pilot flying.

1.17.6.2 Flare and landing

The FCTM, in the Normal Operations – Landing section, presents the flare technique, which states that "in stabilized approach conditions the flare altitude is close to 30 ft. The flare shall be commenced with firm backward pressure on the longitudinal control stick, to be maintained as necessary. Avoid moving the control stick forward once the flare is initiated (the backward pressure may be relaxed)."

As concerns the lateral and directional control of the aircraft in crosswind conditions, the FCTM states that the approach must be flown with the wings level and at a crab angle with the aircraft positioned on the runway centerline extension until the flare.

The recommended technique for eliminating the crab angle involves using the rudder to align the airplane with the runway heading during the flare and, if necessary, using the ailerons to keep the aircraft on the runway centerline. If there is a crosswind, the PF must be ready to add a small roll angle to avoid moving in the direction of the wind and keep the aircraft centered over the runway. The aircraft can land with a residual crab angle of up to 5º to avoid an excessive roll correction.

1.17.6.3 Landing run

The FCTM states that during the landing run, the rudder pedals will be used to steer the aircraft and keep it centered on the runway. At high speeds, directional control is provided by the rudder. When the speed drops, the nosewheel steering system (NWS) takes over directional control, although the pilot must refrain from using the tiller until the aircraft's speed drops to taxi speed. This technique also applies to crosswind landing situations, in which the pilot must avoid moving the control stick toward the windward side, since this increases the weathercock effect[24] by generating a differential force on the wheels that increases the aircraft's tendency to turn into the wind.

The Airbus document *"Flight Operations Briefing Notes -Landing Techniques – Crosswind Landings"* explains this limitation by arguing that if the into-wind roll control is used, the movement of the aileron produces a drag effect that decreases the lift on the into-wind wing, thus resulting in an increased load on the into-wind landing gear. This increases the friction force on the corresponding tires, causing more braking. This will create a tendency for the aircraft to turn into the wind, this contributing to the weathercock effect.

The use of reversers produces a destabilizing effect on the wind flow around the rudder surface, diminishing its effectiveness. If lateral control problems arise during strong crosswind landings, the pilot must consider adjusting the reverse thrust to idle.

[24] The weathercock effect is the aircraft's tendency to turn into the wind.

1.18 Additional information

1.18.1 Flight planning

The Flight Plan was prepared as per the adverse weather procedure in effect at the time, due to which, and in light of the weather conditions at Bilbao and Santander, Barcelona (the departure airport) was selected as the alternate. This required 5945 kg of fuel, with a minimum diversion fuel of 3232 kg.

For weather reasons, the crew decided to add 800 kg of extra fuel, and as a result the final fuel amount onboard was 6750 kg.

The amount of fuel remaining after the go-around maneuver following the first approach was 4051 kg.

Upon landing, the amount of fuel onboard was 3300 kg, and the aircraft's landing weight was 55665 kg.

The crew calculated the FLD considering the actual approach conditions as well as a 10-kt increase over Vref.

The resulting FLD included a 380-m margin with respect to the LDA.

1.19 Useful or effective investigation techniques

N/A

2 ANALYSIS

2.1 General aspects

The aircraft was on a commercial flight from the Barcelona to the Bilbao airports. The flight crew consisted of a captain who was instructing a first officer who was being trained for promotion to captain. The pilot flying this leg was the captain, seated in the CM2 (RH) position.

The weather information for the day of the incident indicated the presence of significant weather events, namely strong and gusty winds from the southwest at up to 70 km/h. The reading for 06:52 showed a wind speed of 45 km/h from 220º. The weather forecast already indicated the presence of strong, gusty winds from the southwest. At 06:00 UTC, a surface wind warning published the previous day had expired. The forecast conditions satisfied the airline's criteria for evaluating weather forecasts, contained in its OM A as instructions for preparing the flight.

Given this information, the crew decided to load 800 kg of extra fuel. The alternate considered was the Barcelona Airport and the final fuel load was 6750 kg, with a minimum diversion fuel of 3232 kg.

During the flight, the crew discussed the possibility of having to execute more than one go-around, as well as the effect of the reversers on controlling the aircraft on the ground. The captain also recommended the practice of using the brakes if the rudder was not sufficient to maintain heading on the runway if there was a crosswind present.

Before the descent, the crew did a FOLD calculation, as required by company procedures. They established landing parameters based on selecting a slats/flaps CONF 3, dry runway and MEDIUM autobrake. The corrected and factored result yielded a distance of 1760 m, which provided a margin of 380 m over the published LDA for runway 30. This value did not take into account the effect of the reversers.

2.2 First approach

They flew the first ILS approach in landing configuration CONF 3, as specified in the Operations Manual, Part B, preferring the advantages that this configuration offers if windshear is encountered, over those of CONF FULL with the autobrake set to MED, specified in the airline's operational briefing for the Bilbao Airport, which requires a longer braking distance. For this first approach, the crew set a Vapp target speed of 136 kt (VLS+5), as confirmed by the CVR.

During the first maneuver, the captain informed the copilot of the need to know the speed of the wind gusts, and not just the stable wind, which ATC was providing. The operator has a wind limit, including gusts, of 40 kt for flying the approach. Since in the case of strong, gusty winds, this value is operationally significant, the possibility remains of issuing a recommendation to have Air Navigation providers instruct their controllers to give wind gust information to crews.

As they were descending through 1000 ft with stabilized approach criteria, a sudden change in wind speed and direction created a windshear situation that was detected by the aircraft's reactive system, which displayed the relevant indication for two seconds.

The crew reacted correctly and initiated the published go-around maneuver. The fact that the reactive signal was present for a length of time well below that described in the manuals (15 sec) led the crew to doubt if the windshear condition detected was real, even commenting that the situation did not seem bad enough to trigger a windshear warning.

They subsequently received vectors to hold over point SARRA.

2.3 Second approach and landing

In its operational briefing on the Bilbao Airport, the operator states that "*When the wind is coming from the directions between 160º and 270º at a speed of 20 kt or more, and there are no favorable pilot reports (PIREPS), expect moderate turbulence on final. Be prepared to execute a go-around and divert in this situation.*"

While they were flying to SARRA and when in the holding pattern, the crew assessed the situation based on the outcome of an approach being flown by another Vueling aircraft.

There were no reports from the pilots of that aircraft, and so the crew decided to make a second approach instead of diverting to their planned alternate. The crew also stated that the turbulence they encountered was not as severe as expected, and that they thus did not expect to receive a windshear warning.

According to the CVR recordings and the pilots' own statement, the target speed used for the second approach was 141 kt, that is, a +10-kt correction over the 131-kt VLS, which was within the allowed margins of up to +15 kt over VLS.

They flew the second approach with the same configuration as in the first, and with wind values slightly below those of the first maneuver.

As they descended through 1000 ft, all of the stabilized approach criteria were met, the ground spoilers were armed and the autobrake system was set to MED.

Near 400 ft, they disengaged both autopilots and the captain took manual control of the aircraft from the CM2 position, as recommended in the FCTM "to assess the drift before the flare." Shortly afterward, the calibrated airspeed (CAS) rose for 12 seconds, reaching values that exceeded the stabilized approach criteria (Vapp -5/+10). According to their statement, the crew thought they could recover from this deviation with a minor correction, so they continued the approach, in keeping with the contents of the standard operating procedures provided in the FCOM.

During the final approach, the crew received up to four reports from the control tower, informing them that the wind at the runway 30 threshold was from 220º to 240º at 11 to 20 kt.

The flare maneuver was initiated descending through 60 ft (30 ft higher than recommended in the FCTM) at a CAS of 142 kt, which increased to an IAS of 150 kt during the execution of the maneuver (Vapp+9). They made inputs to the control stick that spanned the entire backward length of travel to increase the pitch angle, followed by fast inputs to the stick to the halfway point of its forward travel. In this regard, Airbus recommends avoiding this type of forward stick motion once the flare is initiated. The lateral control technique made it possible for the aircraft to touch down on the runway centerline on a heading of 294º (QFU-4º). Twelve seconds elapsed between the flare maneuver and the touch down.

The excess altitude lengthened the distance between the start of the flare maneuver and the touch down, and resulted in the aircraft contacting the runway 740 meters away from the threshold at an IAS of 141 kt[25] (value of the selected Vapp).

In their statement, the crew explained that they took the available margin into account in their planning in the event that the landing maneuver resulted in a long landing.

In its Operations Manual B, the operator states that “the PF must initiate the published go-around procedure whenever... d) the airplane will not land within the TDZ (300 m before to 600 m after the TDZ).”

The wording of this statement is confusing since, although it makes it clear that the aircraft must not land outside the TDZ, it is not clear in detailing the limits, and perhaps even seems to provide an additional 600-m margin to the TDZ.

In the airline’s Operations Manual C in effect at the time of the operation (Rev. 03 of 18 February 2016), the sheet for the Bilbao Airport contains a photograph of the runway 30 threshold that shows a 900-m TDZ marking that was not in effect at the time.

When these discrepancies were reported to the operator, it revised the relevant documents and subsequently corrected the deficiencies described.

Once the aircraft landed 140 meters beyond the TDZ, the crew should have executed a go-around and aborted the landing maneuver. However, the crew’s perception of the simple markings that *delimited the previous TDZ, which were visible, but faint, contributed* to their erroneous perception of the extent of the TDZ, and thus they did not consider the execution of a go around.

Although the crew made no mention of this, according to information provided by AENA, the signal lights in the touchdown zone were on at the time of landing. These lights, as is required in this case, indicate a TDZ of 900 m, which clearly do not match the TDZ of 600 m defined by the touchdown zone sign.

Since the goal of both runway markings and lights is to delimit the TDZ, there was an inconsistency between these dimensions. As a result, a safety recommendation is issued to the certifying authority to have it standardize the distances that signal the TDZ in both systems.

For 7 seconds after touching down, the aircraft decelerated normally, aided by the extended ground spoilers, the autobrake and the extended reversers. Only slight inputs to the rudder pedals were required to keep the airplane centered on the runway.

The aircraft then started turning to the left, with no apparent input from the crew or any abnormal system operation that could have caused it. The ground speed was 119 kt. At the time the FDR recorded a difference in the readings for the two angle of attack sensors that is consistent with a wind gust. This is not confirmed by the wind readings in the FDR, since these readings are not valid once on the ground.

[25] The average time for a standard flare maneuver is 7 seconds, according to Airbus, with a touchdown speed that is 96% of Vapp. Based on these values, the airplane should have touched down at an IAS of 135 kt.

This potential gust, with the aircraft in a high-energy state, destabilized the landing path. The crew took corrective actions using the rudders and brakes (disengaging the autobrake) and set the reversers to IDEL REV power to reduce the weathercock effect on the aircraft and increase their control of the aircraft, as specified in the FCTM. The FDR recordings show the temporary retraction of both reversers, followed by the asymmetric deployment of the right reverser, without an increase in the differential thrust from the engines. The aerodynamic effect produced by the uneven deployment of the reversers could have made it more difficult to control the aircraft, which could have contributed to diverting the airplane in the opposite direction (to the right of the runway) for 4 seconds (see Appendix 4).

After diverting to the left, the crew attempted to return to the runway centerline by making inputs to the rudder and right brake. The fact that they overran the centerline indicates that their inputs were inadequate (either in duration or intensity), made more difficult by the variable wind gust conditions that caused the deviation in the first place.

After the aircraft moved to the right of the runway, the crew made corrective inputs that resulted in the aircraft once again veering to the left of the centerline. This time, the aircraft moved in such a way that it momentarily went off the runway, damaging a runway edge light, an exit taxiway sign and a conduit on the runway strip with its left main landing gear leg.

The crew again applied maximum reverser thrust and maximum rudder pedal deflection and differential braking. At that time the aircraft's ground speed was 50 kt.

It is possible that following the long landing, the reduced runway length remaining could have conditioned the crew's actions to recover from the destabilized landing run.

According to the pilots' statements and the FDR readings, during the maneuver they moved the side stick in an effort to control the roll and keep the wings level. This is contrary to the contents of the manufacturer's FCTM, which states that the side stick should not be moved during the landing run since in crosswind situations, in can intensify the aircraft's weathercock effect. The lateral inputs to the control stick were made in the correct direction to try to maintain an equal weight distribution on the four main wheels and thus optimize the braking action, but it is difficult to determine if the magnitude of these corrections was excessive and could have contributed to destabilizing the landing run.

The crew eventually stopped the aircraft, exited the runway and inspected the brakes and the damage to the aircraft.

According to the information provided by ATS, the wind and gust values could have differed by 10 to 15 kt between the two thresholds.

3 CONCLUSIONS

3.1 Findings

The information available, as well as an analysis of said information, have yielded the following findings:

- The aircraft's documentation was valid and in force.
- The crewmembers had valid and in force licenses, ratings and medical certificates.
- The crew were experienced on the aircraft type.
- It was a captain checkout flight for the first officer in which the captain was acting as the PF.
- The weather forecast indicated the presence of gusting winds from the west/southwest. At 06:00, a surface wind warning published the day before expired.
- The crew executed a go-around on the first approach due to a reactive windshear warning.
- After assessing the operational factors, the crew decided to fly a new approach.
- At the end of the second approach, the calibrated airspeed (CAS) exceeded the stabilized approach values for 12 seconds (Vapp+10).
- The aircraft landed on the runway centerline, 140 meters beyond the TDZ.
- The crew did not realize they had landed outside the TDZ in effect due to mistakenly perceiving the TDZ dimensions and to using old markings as a reference.
- The distances for the TDZ signs, whether markings or lights, do not match.
- For 7 seconds, the aircraft's deceleration was constant and along the runway centerline heading.
- There was an initial deviation to the left of center. The investigation was unable to find any evidence of a crew action or an aircraft system fault that could account for it.
- A difference in the angle of attack sensors when the deviation occurred is consistent with a wind gust from the left of the airplane.
- The crew made inputs to the rudder pedals, differential braking and reversers.
- The crew were unable to prevent the aircraft from swerving to the left and right of the runway centerline, until, during the second deviation to the left, the left main landing gear wheel momentarily veered off the runway, damaging a runway edge light, an exit taxiway sign and a conduit on the runway strip.

- According to information provided by ATS, the wind and gust values could have differed by 10 or 15 kt between the two thresholds.
- The aircraft sustained minor damage, consisting of dents in the left engine housing and detached material from one of the nose gear wheels.

3.2 Causes/Contributing factors

The investigation was unable to determine the main reason for the deviation from the aircraft’s initial path toward the left of the runway centerline. The FDR data allow for a gust of wind to have contributed to the initial change in the aircraft’s landing run while the aircraft was in a high-energy state.

The following contributing factors impeded the control of the aircraft:

- The early start of the flare maneuver, in contrast to the manufacturer’s recommendation, caused the landing to extend 140 meters beyond the TDZ in effect.
- An exessive corrective action in the crew’s effort to return to the runway centerline after the sudden deviation from their landing run.
- The asymmetric deployment of the thrusters when their thrust was reduced to improve lateral control.

4 SAFETY RECOMMENDATIONS

Initially, the Commission considered issuing two safety recommendations to the operator, due to the confusing indications provided in its Operations Manual B regarding the limits of the TDZ, and to the fact that in its Operations Manual C, the sheet for the Bilbao Airport contained a photograph of the runway 30 threshold that showed a 900-m marking for the TDZ that was not in effect.

Since these deficiencies were corrected over the course of the investigation by the operator, it is not necessary to issue said safety recommendations.

However, given the inconsistency between the dimensions of the runway markings and lights that indicate the TDZ, the following safety recommendation is issued:

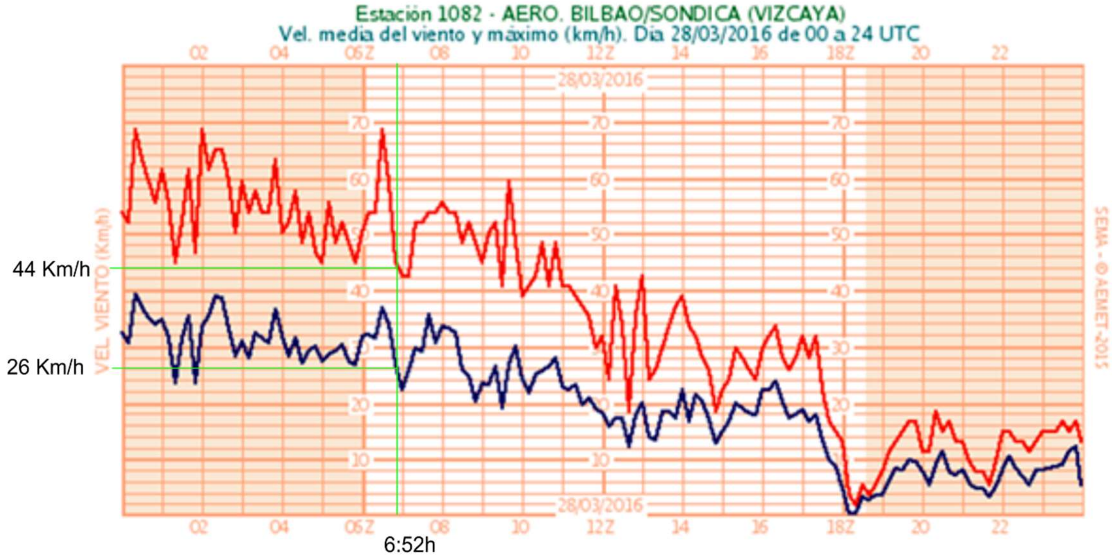
REC 05/19. It is recommended that EASA amend the Certification Specifications and Guidance Material for Aerodromes Design CS-ADR-DSN so as to standardize the distances for the touchdown zone signs, whether they are markings or lights.

APPENDICES

APPENDIX A

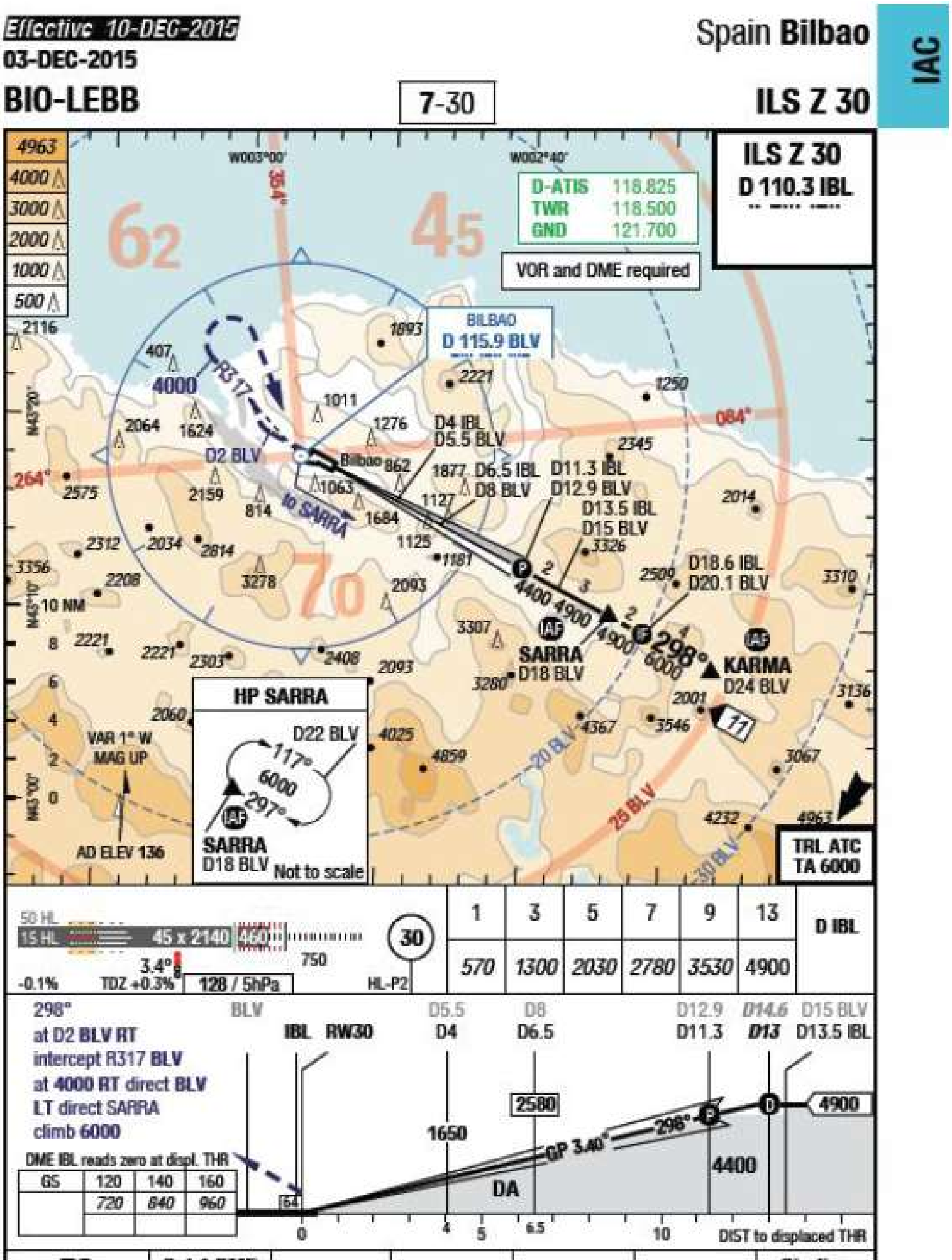
Graphs of wind direction and speed recorded at the weather station


Estación 1082 - AERO. BILBAO/SONDICA (VIZCAYA)
Dirección del viento. Día 28/03/2016 de 00 a 24 UTC
220º
6:52h
DIR. VIENTO
SEMA - ©AEMET-2015


Estación 1082 - AERO. BILBAO/SONDICA (VIZCAYA)
Vel. media del viento y máximo (km/h). Día 28/03/2016 de 00 a 24 UTC
44 Km/h
26 Km/h
6:52h
VEL. VIENTO (Km/h)
SEMA - ©AEMET-2015

APPENDIX B

LIDO chart for ILS Z approach to runway 30 at LEBB

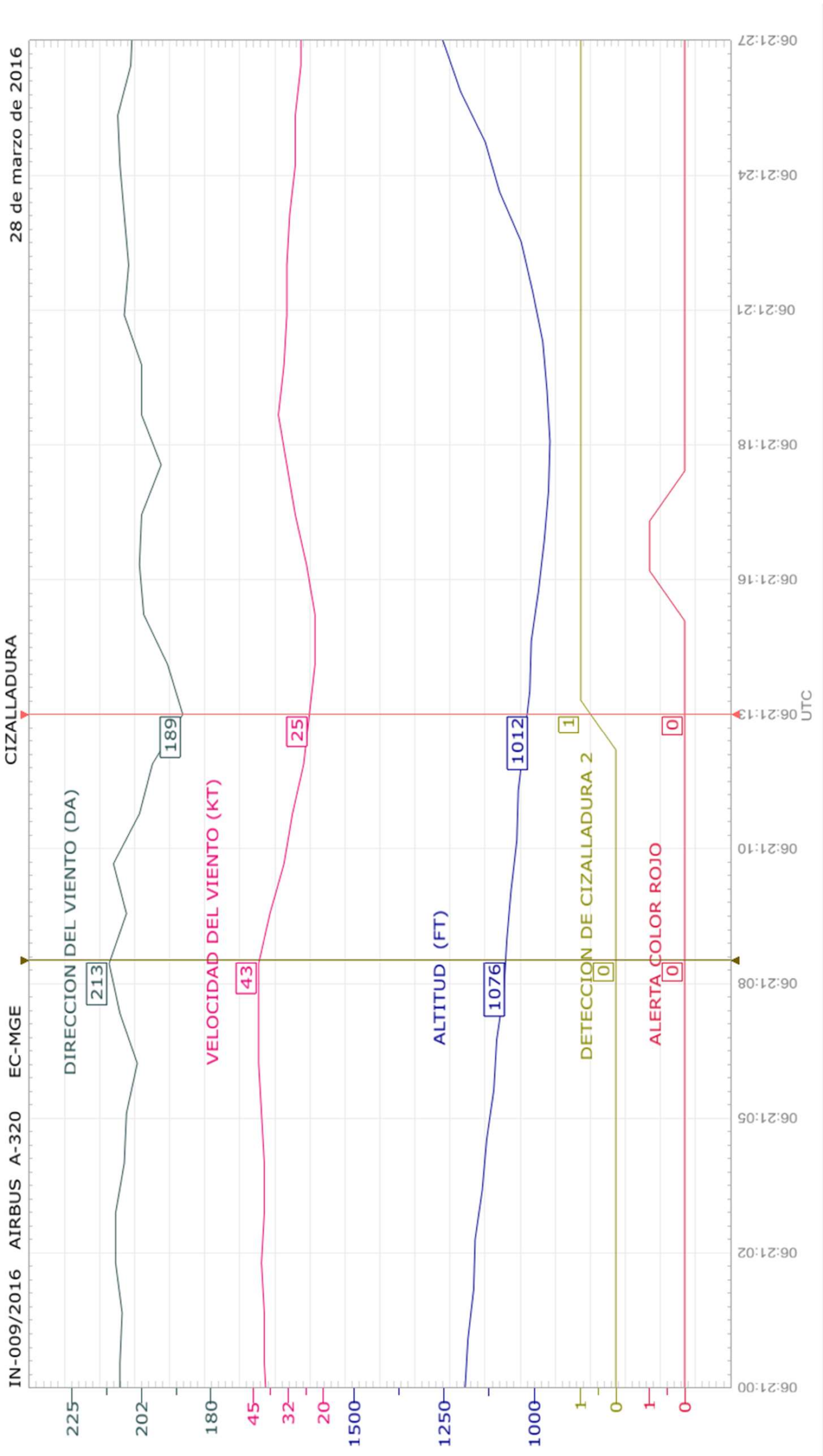


30		Cat 1 DME 1)					Circling 2)
C	ft - m/km ft	310 - 700 440					1930 - 2.4V 2060
D	ft - m/km ft	320 - 700 450					1930 - 3.6V 2060

1) With EVS 550m, wo EVS use STD
2) BTN 291° and 135° of RWY only

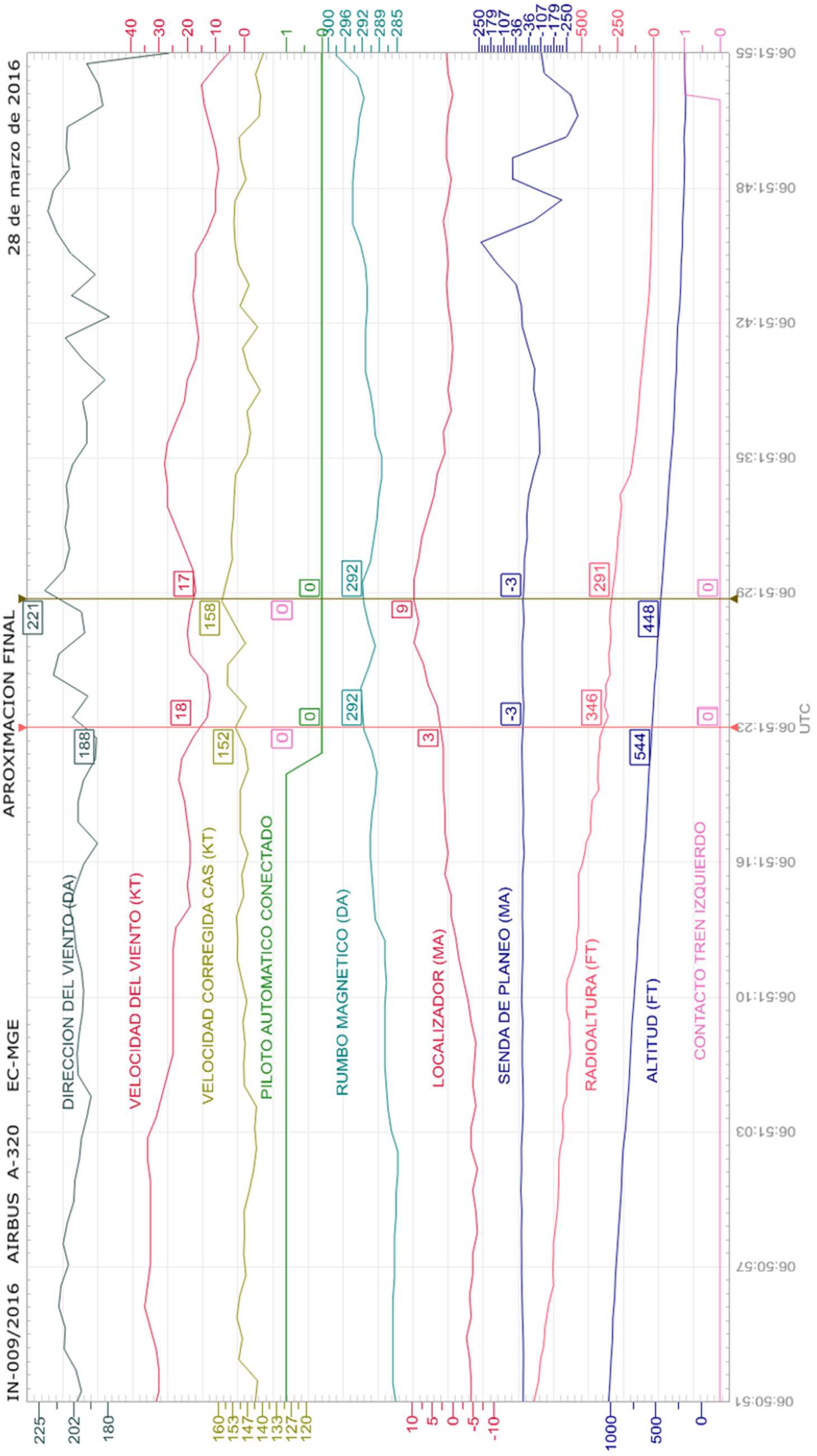
APPENDIX C

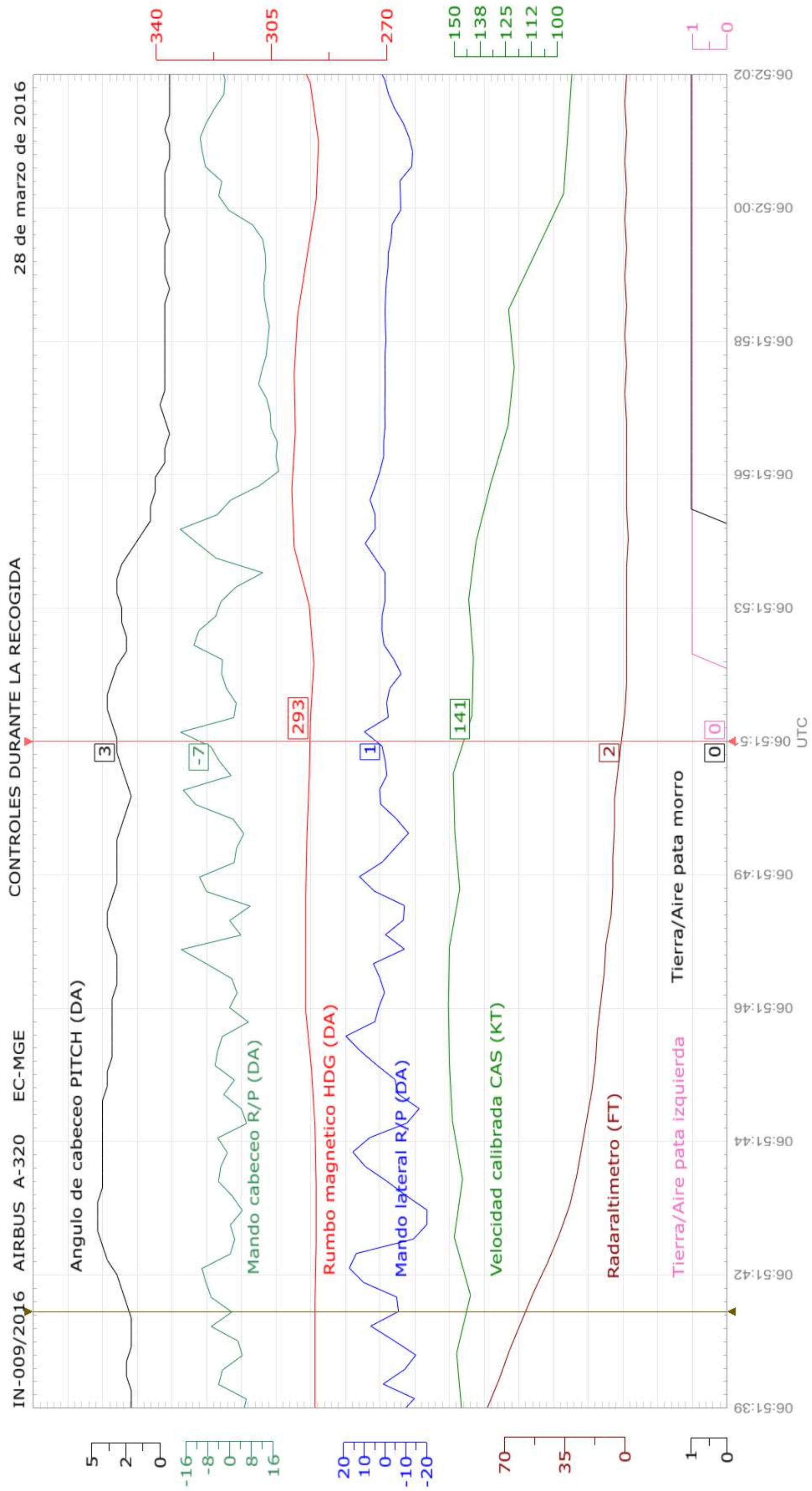
Activation of reactive windshear warning system


IN-009/2016 AIRBUS A-320 EC-MGE
28 de marzo de 2016
CIZALLADURA
DIRECCION DEL VIENTO (DA)
VELOCIDAD DEL VIENTO (KT)
ALTITUD (FT)
DETECCION DE CIZALLADURA 2
ALERTA COLOR ROJO
213
189
43
25
1076
1012
0
1
0
0
225
202
180
45
32
20
1500
1250
1000
1
0
1
0
06:21:00
06:21:02
06:21:05
06:21:08
06:21:10
06:21:13
06:21:16
06:21:18
06:21:21
06:21:24
06:21:27
UTC

APPENDIX D

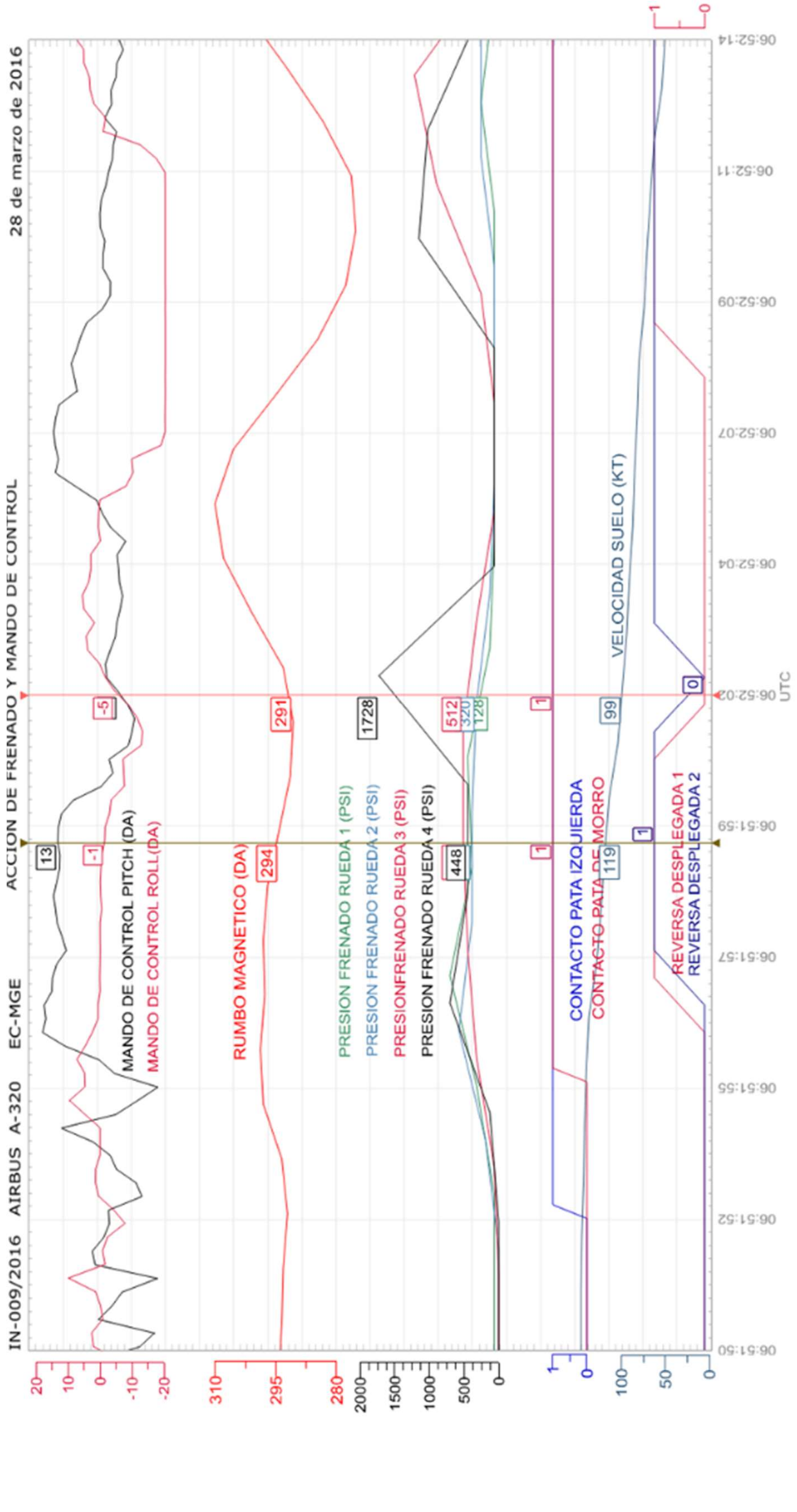
Final approach parameters

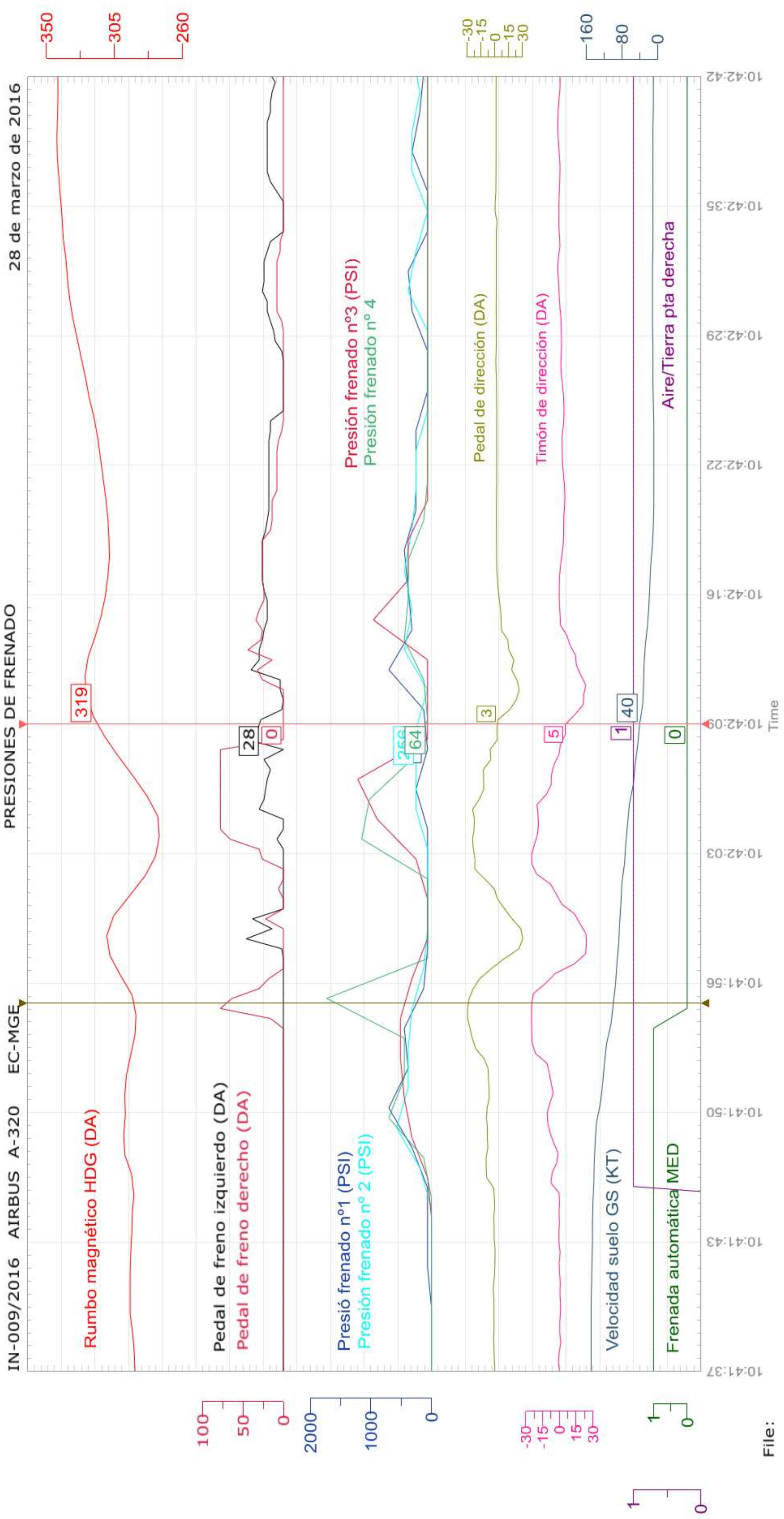

IN-009/2016 AIRBUS A-320 EC-MGE
APROXIMACION FINAL
28 de marzo de 2016
DIRECCION DEL VIENTO (DA)
VELOCIDAD DEL VIENTO (KT)
VELOCIDAD CORREGIDA CAS (KT)
PILOTO AUTOMATICO CONECTADO
RUMBO MAGNETICO (DA)
LOCALIZADOR (MA)
SENDA DE PLANEO (MA)
RADIOALTURA (FT)
ALTITUD (FT)
CONTACTO TREN IZQUIERDO
UTC
06:50:51
06:50:57
06:51:03
06:51:10
06:51:16
06:51:23
06:51:29
06:51:35
06:51:42
06:51:48
06:51:55
188
221
18
17
152
158
0
0
0
292
292
3
9
-3
-3
346
291
544
448
0
0

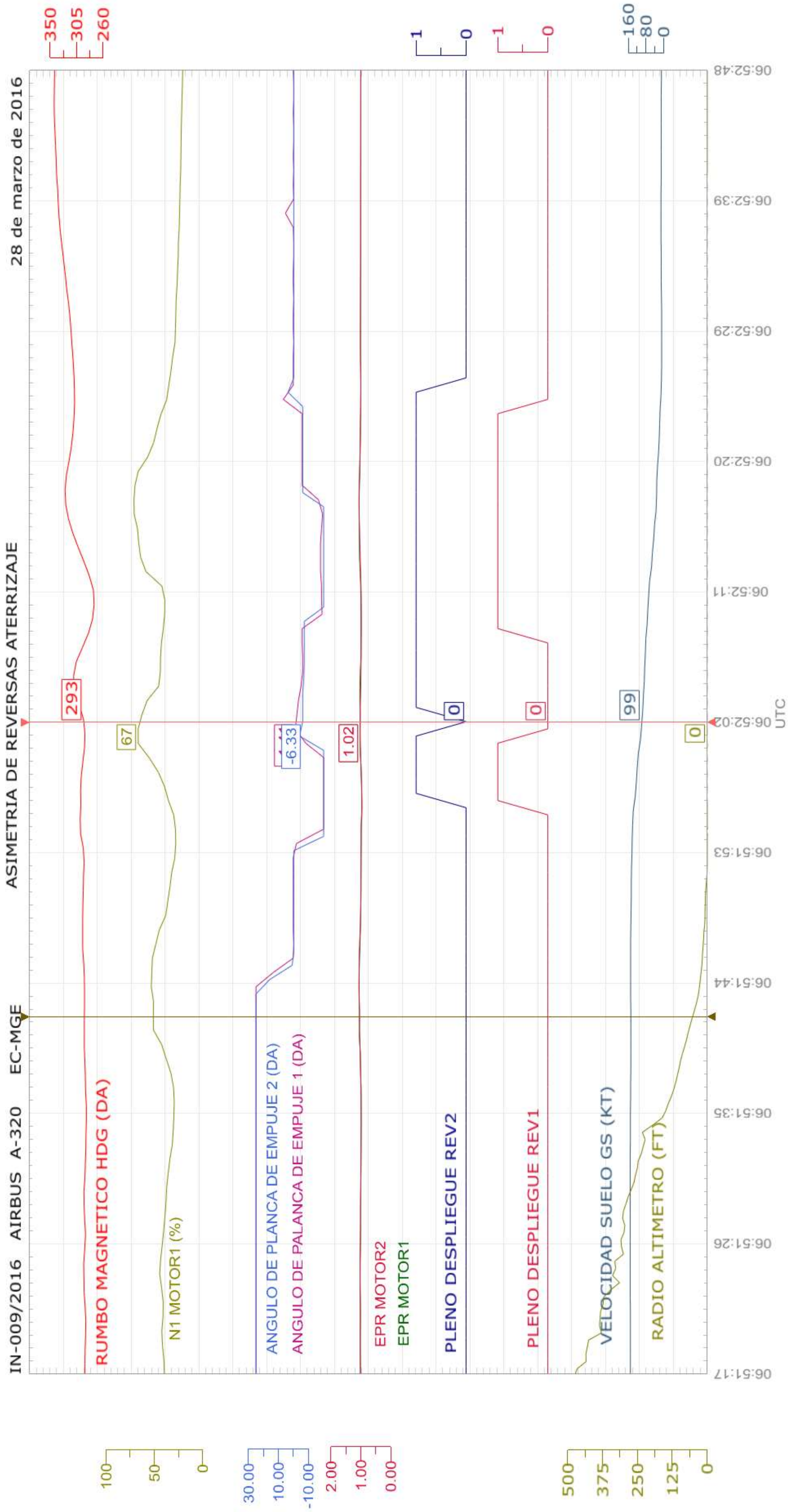

IN-009/2016 AIRBUS A-320 EC-MGE
CONTROLES DURANTE LA RECOGIDA
28 de marzo de 2016
Angulo de cabeceo PITCH (DA)
Mando cabeceo R/P (DA)
Rumbo magnetico HDG (DA)
Mando lateral R/P (DA)
Velocidad calibrada CAS (KT)
Radaraltimetro (FT)
Tierra/Aire pata izquierda
Tierra/Aire pata morro
06:51:39
06:51:42
06:51:44
06:51:46
06:51:49
06:51:51
06:51:53
06:51:56
06:51:58
06:52:00
06:52:02
UTC
340
305
270
150
138
125
112
100
293
141
3
-7
1
2
0
0
5
2
0
-16
-8
0
8
16
20
10
0
-10
-20
70
35
0
1
0

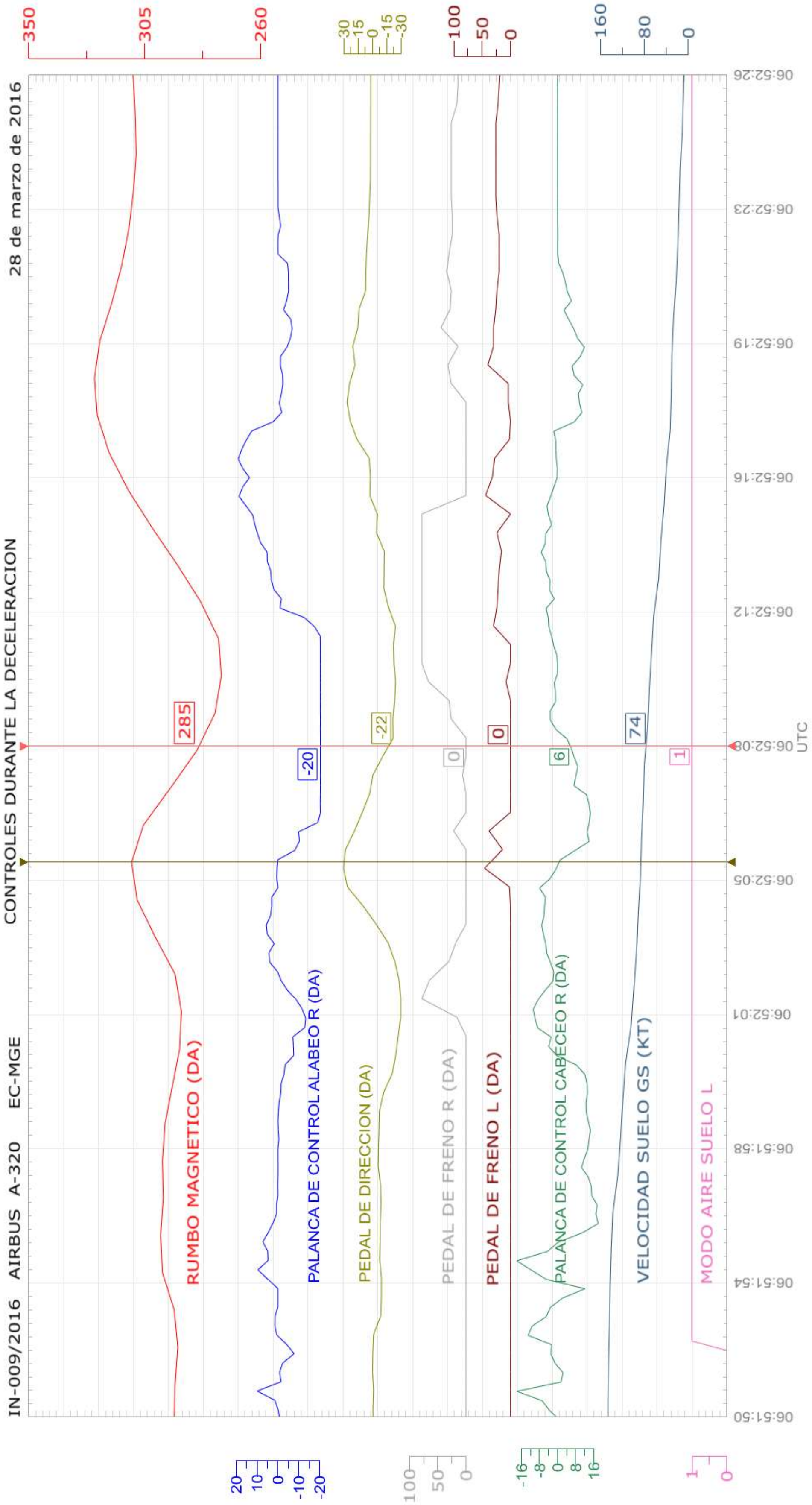
APPENDIX E

Braking action, use of reversers and side stick inputs


IN-009/2016 AIRBUS A-320 EC-MGE
ACCION DE FRENADO Y MANDO DE CONTROL
28 de marzo de 2016
MANDO DE CONTROL PITCH (DA)
MANDO DE CONTROL ROLL(DA)
RUMBO MAGNETICO (DA)
PRESION FRENADO RUEDA 1 (PSI)
PRESION FRENADO RUEDA 2 (PSI)
PRESIONFRENADO RUEDA 3 (PSI)
PRESION FRENADO RUEDA 4 (PSI)
CONTACTO PATA IZQUIERDA
CONTACTO PATA DE MORRO
VELOCIDAD SUELO (KT)
REVERSA DESPLEGADA 1
REVERSA DESPLEGADA 2
13
-1
294
448
1
119
1
-5
291
1728
512
320
128
1
99
0
20
10
0
-10
-20
310
295
280
2000
1500
1000
500
0
1
0
100
50
0
1
0
06:51:50
06:51:52
06:51:55
06:51:57
06:51:59
06:52:02
06:52:04
06:52:07
06:52:09
06:52:11
06:52:14
UTC

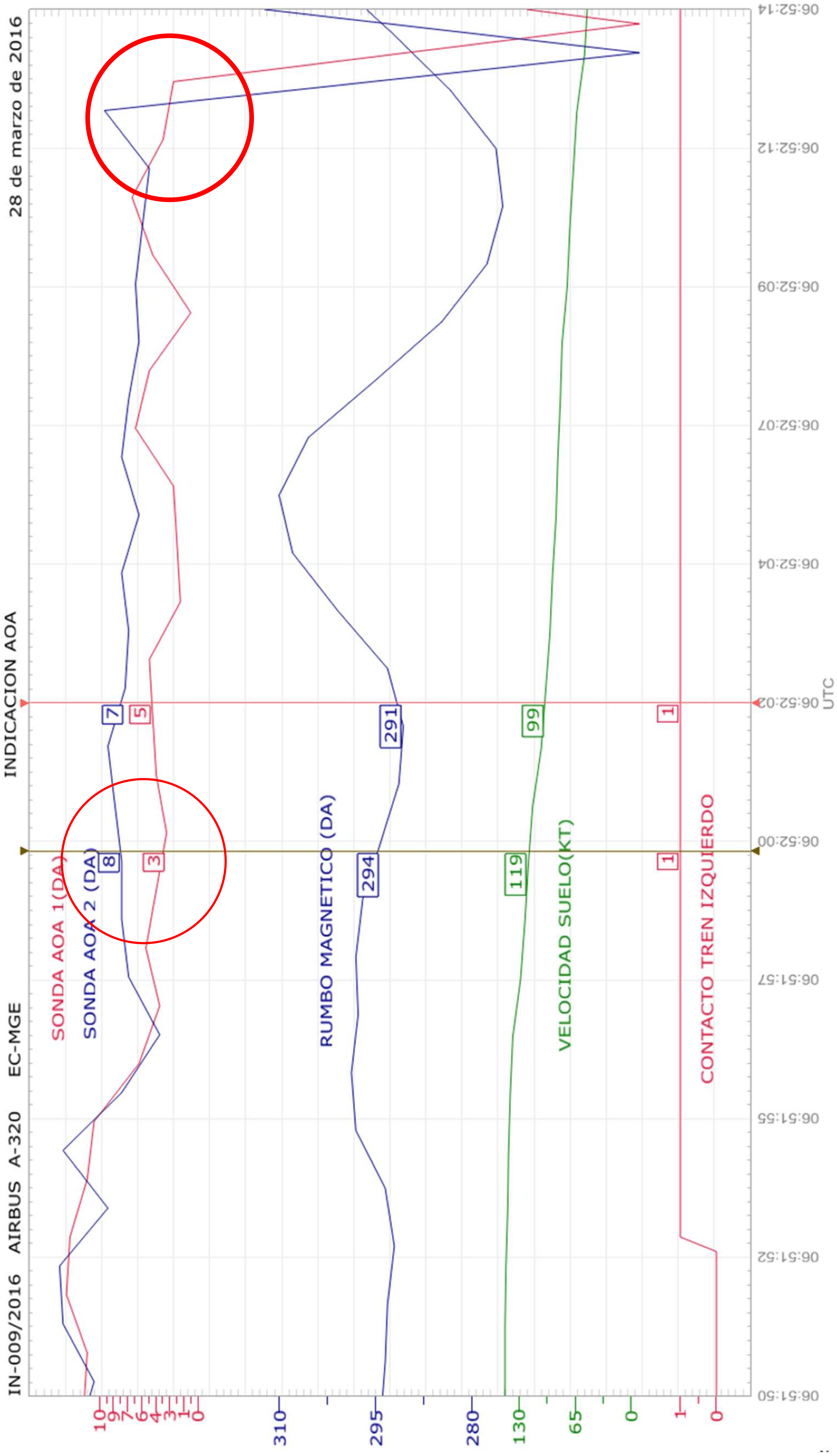

IN-009/2016 AIRBUS A-320 EC-MGE
PRESIONES DE FRENADO
28 de marzo de 2016
Rumbo magnético HDG (DA)
Pedal de freno izquierdo (DA)
Pedal de freno derecho (DA)
Presió frenado nº1 (PSI)
Presión frenado nº 2 (PSI)
Presión frenado nº3 (PSI)
Presión frenado nº 4
Pedal de dirección (DA)
Timón de dirección (DA)
Velocidad suelo GS (KT)
Aire/Tierra pta derecha
Frenada automática MED
319
28
0
256
64
3
5
1
40
0
350
305
260
100
50
0
2000
1000
0
-30
-15
0
15
30
160
80
0
1
0
10:41:37
10:41:43
10:41:50
10:41:56
10:42:03
10:42:09
10:42:16
10:42:22
10:42:29
10:42:35
10:42:42
Time
File:


IN-009/2016 AIRBUS A-320 EC-MGE
ASIMETRIA DE REVERSAS ATERRIZAJE
28 de marzo de 2016
RUMBO MAGNETICO HDG (DA)
N1 MOTOR1 (%)
ANGULO DE PLANCA DE EMPUJE 2 (DA)
ANGULO DE PALANCA DE EMPUJE 1 (DA)
EPR MOTOR2
EPR MOTOR1
PLENO DESPLIEGUE REV2
PLENO DESPLIEGUE REV1
VELOCIDAD SUELO GS (KT)
RADIO ALTIMETRO (FT)
293
67
-6.33
1.02
0
0
99
0
UTC
06:51:17
06:51:26
06:51:35
06:51:44
06:51:53
06:52:02
06:52:11
06:52:20
06:52:29
06:52:39
06:52:48
350 305 260
100 50 0
30.00 10.00 -10.00
2.00 1.00 0.00
1 0
1 0
160 80 0
500 375 250 125 0


IN-009/2016 AIRBUS A-320 EC-MGE
CONTROLES DURANTE LA DECELERACION
28 de marzo de 2016
RUMBO MAGNETICO (DA)
PALANCA DE CONTROL ALABEO R (DA)
PEDAL DE DIRECCION (DA)
PEDAL DE FRENO R (DA)
PEDAL DE FRENO L (DA)
PALANCA DE CONTROL CABECEO R (DA)
VELOCIDAD SUELO GS (KT)
MODO AIRE SUELO L
UTC

APPENDIX F

Angle of attack (AOA) readings


IN-009/2016 AIRBUS A-320 EC-MGE
28 de marzo de 2016
INDICACION AOA
SONDA AOA 1(DA)
SONDA AOA 2 (DA)
RUMBO MAGNETICO (DA)
VELOCIDAD SUELO(KT)
CONTACTO TREN IZQUIERDO
UTC
06:51:50
06:51:52
06:51:55
06:51:57
06:52:00
06:52:02
06:52:04
06:52:07
06:52:09
06:52:12
06:52:14
10 9 7 6 4 3 1 0
310
295
280
130
65
0
1
0
8
3
294
119
1
7
5
291
99
1