CIAIAC

COMISIÓN DE
INVESTIGACIÓN
DE ACCIDENTES
E INCIDENTES DE
AVIACIÓN CIVIL

Report A-029/2011

Accident involving a Bombardier CL-600-2B19 (CRJ200), registration EC-ITU, operated by Air Nostrum, at the Barcelona Airport, on 30 July 2011

GOBIERNO DE ESPAÑA
MINISTERIO DE FOMENTO

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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.

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Abbreviations

00°	Sexagesimal degrees
00 °C	Degrees centigrade
ADC	Air Data Computer
AESA	Spain's Aviation Safety Agency
AGL	Above Ground Level
AIP	Aeronautical Information Publication
AMM	Aircraft Maintenance Manual
ASIAS	Aviation Safety Information Analysis and Sharing Program
ATC	Air Traffic Control
ATIS	Automatic Terminal Information Service
ATPL(A)	Airline Transport Pilot License (airplane)
CAA	Civil Aviation Authority (United Kingdom)
CB/Cb	Cumulonimbus
CRM	Cockpit Resource Management
CVR	Cockpit Voice Recorder
DFDR	Digital Flight Data Recorder
E	East
EGPWS	Enhanced Ground Proximity Warning System
EICAS	Engine Indication and Crew Alerting System
EU OPS	European Union regulations on the harmonization of technical requirements and administrative procedures in the field of civil aviation
F/O	First Officer
FA	Flight Attendant
FAA	Federal Aviation Administration (USA)
FDM	Flight Data Monitoring
FDR	Flight Data Recorder
FH	Flight Hours
FL	Flight level
FLT	Flight crew intercom
FMS	Flight Management System
FSF	Flight Safety Foundation (USA)
FSO	Flight Safety Organization
fpm	Feet per minute
ft	Feet
ft/min	Feet/minute
g	Acceleration due to gravity
GLD	Ground Lift Dumping
GMC	Ground Movement Control
GND	Ground
GS	Ground speed/Glide slope (ILS subsystem)
h, hr	Hour(s)
hPa	Hectopascals
HRV	High Resolution Visible
IAS	Indicated airspeed
ICAO	International Civil Aviation Organization
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
IR	Instrument Rules
IRS	Inertial Reference System
IVS	Inertial Vertical Speed
JAA	Joint Aviation Authorities
kg	Kilogram(s)
km	Kilometer(s)
kt	Knot(s)
LECB	IACO code for Barcelona airport (Spain)
LH	Left Hand

Abbreviations

LIH	Light Intensity High
LOC	Localizer (ILS subsystem)
m	Meter(s)
MDA/DH/DA	Minimum decision altitude/decision height/decision altitude
MEHT	Minimum Eye Height over Threshold (for visual) approach slope indicator systems
METAR	Aviation routine weather report
MFD	Multifunction display
MHz	Megahertz
min	Minute(s)
mm/h	Milimeters/hour
MSA	Minimum sector altitude
N	North
N1	Low-pressure compressor RPMs
NM	Nautical miles
NTSB	National Transportation Safety Board (USA)
OM A	Operations Manual, Part A
OM B	Operations Manual, Part B
P/N	Part Number
PAPI	Precision Approach Path Indicator
PF	Pilot Flying
PM	Pilot Monitoring
PNF	Pilot Non-Flying
PPI	Plan Position Indicator
PRM	Pilot Reference Manual
QAR	Quick Access Recorder
QMS	Extended runway centerline
QNH	Altimeter subscale setting to obtain elevation when on the ground
RA	Radio Altitude
RGB	Red, Green, Blue
RH	Right Hand
ROD	Rate of Descent
S	South
s	Second(s)
Sc	Scattered
SE	South East
S/N	Serial Number
SIGMET	Information concerning en-route weather phenomena which may affect the safety of aircraft operations
SOP	Standard Operating Procedures
SPECI	Selected special weather report
TAD	Terrain Alert Display
TAFOR/TAF	Aerodrome forecast
TAWS	Terrain Awareness and Warning System (part of the EGPWS)
TCAS	Traffic alert and collision avoidance system
TCF	Terrain Clearance Floor
TDZ	Touchdown zone
TDZE	Touchdown zone elevation
TEM	Threat and error management
TO/GA	Takeoff/Go-around
TWR	Tower
UTC	Coordinated universal time
VFR	Visual Flight Rules
VHF	Very High Frequency
VIP	Video Integrated Processor
VMC	Visual meteorological conditions
VOR	Very high frequency Omni-directional range
Vref	Reference speed
W	West

Synopsis

Owner and operator:	Air Nostrum
Aircraft:	Bombardier Canadair CL-600-2B19 (CRJ200)
Date and time of accident:	Saturday, 30 July 2011; at 15:14:23 UTC
Site of accident:	Barcelona Airport
Persons onboard:	Crew: 3, passengers: 35
Type of flight:	Commercial Air Transport – Scheduled – Domestic – Passenger
Date of approval:	30 January 2013

Summary of accident

On Saturday 30 July 2011, a CRJ-200 aircraft, registration EC-ITU, was making flight ANE 8313 between the airports of Badajoz and Barcelona with 35 passengers and 3 crew onboard.

During this flight the first officer was the PF and the captain was the PM.

The prevailing weather condition in the area of the airport was one of high instability, resulting in the growth of convective clouds with large vertical development causing rain and storms.

The final-25R controller informed the crew that the storm was reaching the area of the runway 25R localizer and asked if they wanted to make a visual approach. The crew opted to do so and the controller cleared them to approach in these conditions.

During the approach they encountered a cloud layer. The PF chose to climb to maintain visual conditions, though doing so caused them to lose visual contact with the runway. By the time visual contact was regained, they were 775 ft above the theoretical glide slope.

They continued the approach using normal descent rates, such that their excess altitude did not drop appreciably. When the aircraft was at about 600 ft AGL, the captain decided to take control of the airplane and became the PF. He deployed the spoilers (air brakes) and increased the descent rate, which reached values in excess of 2,500 ft/min. The excessive descent rate caused the EGPWS to start issuing alerts, which lasted 13 s, until the aircraft reached the radio altitude[1]; from that point these alerts are inhibited by design.

[1] 10 ft if the inertial vertical speed (IVS) data proceed from the inertial reference system (IRS) or 30 ft in case they proceed from the air data computer (ADC).

The aircraft flew over the threshold at a height of 365 ft.

The aircraft contacted the runway forcefully with the nose and right main landing gear legs, resulting in high vertical acceleration values that reached a maximum of 3.66 g's.

The aircraft bounced and became airborne before descending and contacting the runway again, which once more resulted in high vertical accelerations.

After this second contact the aircraft did not bounce. It decelerated normally, exited the runway and headed to its assigned parking stand.

There was damage to the aircraft where the landing gear attaches to the structure.

The investigation has revealed that the accident was caused by the captain's decision to attempt to approach with descent rates in excess of 2,500 feet/minute and with the spoilers deployed from 600 ft to the ground.

The following contributing factors were also identified:

The failure to respond to the EGPWS alerts and a lack of communication between the two pilots.

As a result of the investigation, eight safety recommendations on operational safety are issued, seven of them addressed to the aircraft operator, Air Nostrum, and one to Spain's Aviation Safety Agency (AESA).

1. FACTUAL INFORMATION

1.1. History of the flight

A Bombardier Canadair CL-600-2B19 (CRJ200) aircraft, registration EC-ITU, operated by Air Nostrum, was making scheduled passenger flight ANE 8313 between the airports of Badajoz and Barcelona.

The airplane took off from Badajoz at 13:55, one hour after its scheduled departure time. This delay was due to the late arrival of the aircraft on the preceding flight to the Barcelona Airport.

The aircraft took off from Badajoz with 250 kg of fuel in excess of that required by the operational flight plan, in which Reus was listed as the alternate airport.

The first officer was the pilot flying. The takeoff and cruise phases were uneventful.

Since the aircraft had planned to initiate its descent over Sabadell, north of the airport, the controller suggested modifying the arrival and enter via RULOS to the south, since traffic entering from the north was having to deviate due to the presence of storm formations.

The change seemed reasonable to the crew, since the weather radar was not showing any returns from that area.

Figure 1. Photograph of the aircraft

Once past RULOS, the controller informed them that he would guide them to mile 4 so as to expedite the landing, since the clouds were encroaching on the approach track. He provided them radar vectors to intercept the localizer.

The controller later asked the crew if they could accept a visual approach, to which they replied yes. They were then cleared to make a visual approach to runway 25R.

The aircraft lined up with the runway from a very short distance away. It flew over the 25R threshold at an altitude of 365 ft and a speed of 146 kt.

The high descent rate reached in the final phase of the approach led to a hard landing (3.66 g's), which caused material damage to the aircraft.

The crew informed the airline's maintenance personnel of the hard landing.

1.2. Injuries to persons

Injuries	Crew	Passengers	Others
Fatal			
Serious			
Minor	1		Not applicable
None	2	35	Not applicable
TOTAL	3	35	

The flight attendant injured a muscle in her neck which caused her to be on medical leave for one month.

1.3. Damage to aircraft

The aircraft underwent the hard landing inspection specified in the maintenance manual (AMM 05-51-01) at the Barcelona Airport. This inspection revealed damage to the areas where the landing gear attached to the structure. The repair work had to be performed at the operator's base in the Valencia Airport, meaning the aircraft would have to be taken there on a ferry flight.

The operator asked the aircraft manufacturer about the possibility of flying it to its base. Bombardier provided precise engineering substantiations to do so, which required that certain landing components be replaced first. Based on these requirements the operator asked AESA for their authorization for such positioning flight, which was conceded.

Once these preliminary repairs were made the airplane flew to the Valencia Airport, where the repairs were completed.

1.4. Other damage

There was no additional damage.

1.5. Personnel information

1.5.1. *Captain*

Age:	37 years old
Nationality:	Spanish
License:	ATPL (airplane), valid until 13/12/2013
Ratings:	• IR, valid until 25/04/2012 • CRJ 100/200 valid until 25/04/2012
Medical certificate:	Class 1, valid until 23/09/2011
Total flight hours:	7,331 h
Flight hours on the aircraft type:	6,544 h
Flight activity:	• Previous 90 days: 192:43 h • Previous 30 days: 46:21 h • Previous 24 h: 00:00 h • Rest time before flight: 48:00 h

On the day of the accident he went on duty at 06:55, making first a positioning flight between Madrid and Barcelona. Then, as captain, he flew the segments Barcelona-Badajoz and Badajoz-Barcelona, which was the accident flight. He returned to Madrid that same day on a positioning flight.

1.5.2. *First officer*

Age:	32 years old
Nationality:	Spanish
License:	ATPL (airplane), valid until 18/12/2014
Ratings:	• IR, valid until 30/11/2011 • CRJ 100/200 valid until 30/11/2011

Medical certificate:	Class 1, valid until 10/09/2011
Total flight hours:	3,030 h
Flight hours on the aircraft type:	1,067 h
Flight activity:	• Previous 90 days: 164:31 h • Previous 30 days: 70:25 h • Previous 24 h: 06:07 h • Rest time before flight: 15:19 h

On the day of the accident he had gone on duty at 04:25, making the following flights as first officer:

- Almeria-Seville.
- Seville-Almeria.
- Almeria-Barcelona.
- Barcelona-Badajoz.
- Badajoz-Barcelona.

1.5.3. *FA*

Age:	24 years old
Nationality:	Spanish
License:	FA, valid until 26/04/2012
Ratings:	• ATR42/72 • CRJ100 • DHC8
Medical certificate:	Class 2, valid until 5/04/2016

1.6. Aircraft information

Manufacturer:	Bombardier Inc.
Model:	Canadair CL-600-2B19 (CRJ 200)
Serial number:	7866
Year of manufacture:	2003
Airworthiness certificate:	Valid until 15/01/2012
Engines, number/manufacturer and model:	Two (2)/General Electric CF34-3B1

Dry weight: 13,793 kg

Maximum takeoff weight: 23,133 kg

1.6.1. *Maintenance records*

Before the accident, the aircraft had last been inspected on 29 July 2011, the day before the event.

It was a 2500FH-CHECK-RJ2 inspection and was performed with 19,594 h and 17,761 cycles on the aircraft.

The aircraft was equipped with two CF34-3B1 General Electric engines, the maintenance information for which is as follows:

S/N	Position	Hours (30/07/11)	Cycles (30/07/11)	Scheduled maintenance	Date	FH
872629	RH	29,160	24,786	Hot zone boroscopic (Int: 3,000 FH) Cold zone boroscopic (Int: 5,000 FH)	24/12/2010 20/07/2011	27,895 29,154
873729	LH	20,674	18,391	Hot zone boroscopic (Int: 3.000 FH) Cold zone boroscopic (Int: 5.000 FH)	07/02/2011 07/02/2011	19,744 19,744

1.6.2. *Spoiler system*

The CRJ200 features four spoiler panels located on the top surface of each wing:

- One spoileron (outboard panel)
- One speed brake (air brake)
- Two ground spoilers (two inboard panels)

The spoilerons can be deployed asymmetrically to assist in roll control by improving lateral control at low speeds. The extent to which they are deployed depends on variables such as the control wheel input, Mach number and flaps position.

The speed brakes (air brakes) deploy symmetrically to increase drag and reduce lift. Their extension is proportional to the position of the spoiler control lever. They are used to control speed and to stabilize the airplane on the glide path or during rapid descents.

Their use is limited to above 300 ft AGL. An amber FLT SPLR DEPLOY warning will be lit on the EICAS whenever they are deployed below 800 ft AGL[2], heights described by the operations manual as unsafe.

Ground spoilers deploy fully during the landing run, eliminating lift and increasing drag so as to improve the airplane's stopping ability. In order to dissipate lift, the spoilerons, air brakes and ground spoilers are fully and simultaneously deployed.

In order to activate the Ground Lift Dumping (GLD) system, this must be armed and the following conditions must exist:

- For the ground spoilers and air brakes:

  — The left and right throttle levers must be in the idle position or the N1 value for the left and right engines must be below 40%. At least two of the following conditions must also be present:

    – Weight sensor on the left or right leg activated
    – Wheel speed above 16 kt
    – Radio altitude below 5 ft

  Once at least two of above conditions exist, the system automatically assumes that they will be maintained for 4 seconds; therefore if the engine levers are at idle at any moment within this period, the spoilers will be deployed, even if above conditions cease to be true in that 4 seconds period.

- For the spoilerons:

  — The left and right throttle levers must be in the idle position or the N1 value for the left and right engines must be below 40%.
  — The weight sensor on the left and right leg must be activated and one of the following must be present:

    – Wheel speed above 16 kt
    – Radio altitude below 5 ft

As with the air and ground spoilers, once the condition is fulfilled, the systems considers that it will maintained for 4 seconds.

[2] 800 ft for JAA-approved aircraft and 300 ft for Transport Canada and FAA-approved aircraft.

1.6.3. *Weather radar*

The weather radar on the CRJ200 has a display where the crew can see information on any precipitation that is present and that shows a representation of the ground along the airplane's flight path. The system has a range of 320 NM and up to 60° on either side of the flight path. The information is shown on a multi-function display (MFD) that can integrate said information with navigation data and the TCAS modes.

The radar returns use a color scale to represent the intensity of the precipitation detected, as shown on the table below, taken from the Crew Operations Manual.

Color on screen	Precipitation rate inches/hour (mm/h)	Video integrated processor (VIP) levels		
		Storm category	VIP level	Precipitation rate inches/hour (mm/h)
Purple	>2.1 (>52)	EXTREME	6	>5.0 (>125)
		INTENSE	5	2.0-5.0 (50-125)
Red	0.5-2.1 (12-52)	VERY STRONG	4	1-2 (25-50)
		STRONG	3	0.5-1 (12-25)
Yellow	0.17-0.5 (4-12)	MODERATE	2	0.1-0.5 (2,5-12)
Green	0.04-0.17 (1-4)	WEAK	1	0.01-0.1 (0,25-2,5)
Black	<0.04 (<1)			

1.6.4. *Enhanced Ground Proximity Warning System (EGPWS)*

The EGPWS is a system whose main function is to help in the prevention of accidents caused by unsafe flight maneuvers near the ground or by severe wind shear.

This system issues acoustic alarms, messages and visual signs in case the predefined values are exceeded.

It features different work methods. Mode 1 "excessive descent rate" is used during the approach phase, independently of the aircraft configuration. In this mode the alerts are generated when the aircraft, close to the ground, has an excessive descent rate.

The system has two pre-established limits. In case the outer limit is exceeded, warning lights "GND PROX" activate and an acoustic alarm "SINK RATE" is generated. In case the inner limit is exceeded, warning lights "PULL UP" activate and a repetitive acoustic alarm "WHOOP, WHOOP, PULL UP" is generated.

1.7. Meteorological information

1.7.1. *Forecasts*

Prior to the flight, the crew was given the weather information for the route and destination airport, as detailed below. They were also given information on the departure and alternate airports, which is omitted as it is not relevant to the accident.

The 12:00 UTC significant weather chart between flight levels 100 and 450 for 30 July (Figure 2) had information on a cloud formation on the Mediterranean coast that included the possibility of finding isolated cumulonimbus clouds embedded in it.

SIGMET:
LECB BARCELONA UIR
WS SIGMET 4 VALID 301045/301230 LEMM- LECB BARCELONA
FIR/UIR EMBD TS OBS BTN N3830/N4030 AND E OF E001 TOP
FL390 MOV E NC=

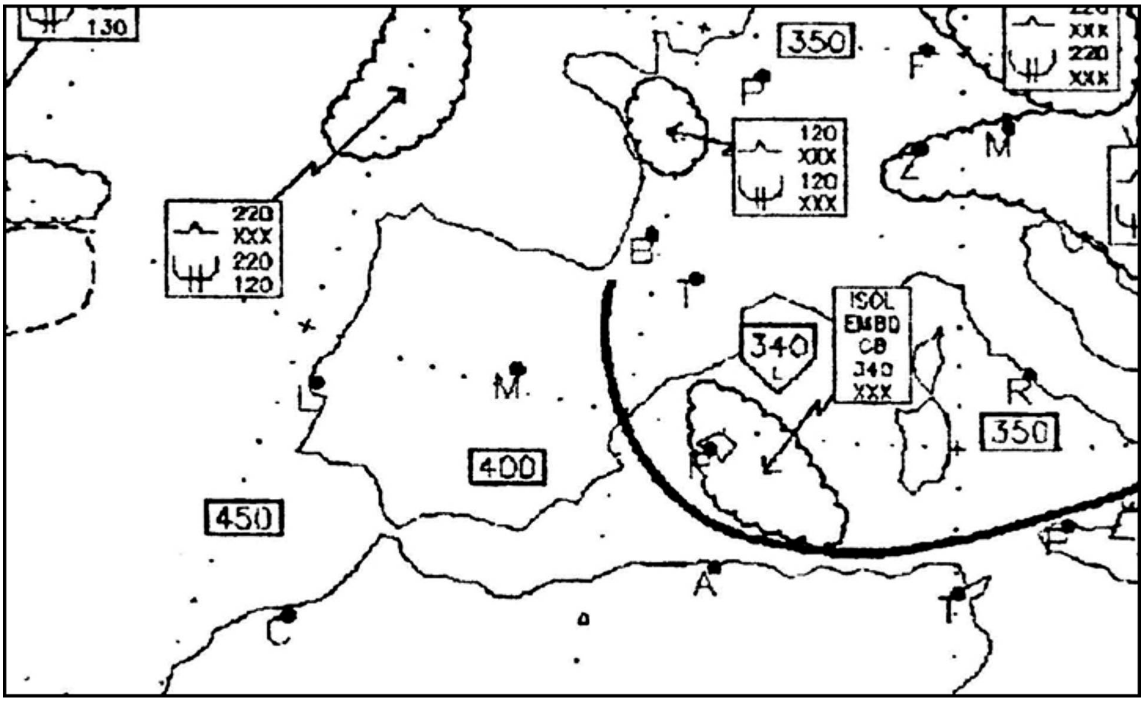


Figure 2. Significant weather chart for 12:00 UTC on 30 July 2011

Interpretation: fourth Sigmet message, valid from 10:45 until 12:30 UTC on the 30th. Intense storms observed between the 38° 30’ N and 40° 30’ N parallels and east of the 01° 00’ meridian, with cloud tops at FL390 moving east with no changes.

12:00 UTC Barcelona Airport METAR:

17010KT 150V210 9999 SCT015 26/21 Q1015 NOSIG=

Interpretation: wind from 170° at 10 kt. In the 10 minutes prior to the observation, the wind direction varied between 150° and 210°. Visibility in excess of 10 km. Scattered clouds (3 to 4 octas) at 1,500 ft. Temperature 26 °C and dew point 21 °C. QNH 1,015 hPa. No significant changes.

Barcelona Airport TAF:

3012/3112 17010KT 9999 SCT022 TX25/3015Z TN21/3104Z
PROB30 TEMPO 3012/3020 4000 SHRA BKN014 SCT018CB
BECMG 3018/3020 VRB04KT=

Interpretation: forecast valid from 12:00 on the 30th until 12:00 on the 31st. Surface winds from 170° at 10 kt. Visibility in excess of 10 km. Scattered clouds (3 to 4 octas) at 2,200 ft. Maximum temperature of 25 °C at 15:00 on the 30th and minimum temperature of 21 °C at 04:00 on the 31st. 30% chance that rain would temporarily reduce visibility to 4,000 m between 12:00 and 20:00 on the 30th. Broken skies (5 to 7 octas) with cloud base at 1,400 ft, scattered cumulonimbus clouds (3 to 4 octas) with a base at 1,800 ft. Wind direction becoming variable between 18:00 and 20:00 at a speed of 4 kt.

1.7.2. *Evolving weather conditions at the airport*

The METARs for the period between 14:00 and 16:00 (from 1:15 hours before the accident until 45 min afterward) are as follows:

14:00 19014KT 9999 SCT015 26/21 Q1014 NOSIG=
14:30 18011KT 9999 SCT015 SCT040 25/20 Q1014 NOSIG=
15:00 17011KT 9999 SCT012CB SCT040 24/21 Q1014 TEMPO TSRA=

A special report (SPECI) was issued at 15:16 due to a storm:

15:16 36019G29KT 340V040 9000 TSRA SCT012CB SCT040 21/16 Q1016 NOSIG=
15:30 01007KT 330V070 3000 1000 TSRA SCT012CB BKN040 19/14 Q1016 NOSIG=
16:00 12019G30KT 090V150 9000 4000 TSRA SCT018CB BKN045 20/16 Q1015 NOSIG=

At 14:00 the SIGMET shown below was issued. It was the fifth to be issued on that day and it was valid from 14:00 to 16:00. It says that storms were observed above Barcelona north of the 41° 30’ parallel, with the tops of the cumulonimbus clouds at flight level 400 and no movement of the storm expected.

WSEW32 LEMM 301400
LECB SIGMET 5 VALID 301400/301600 LEMM-
LECB BARCELONA FIR/UIR FRQ TS OBS BARCELONA N OF N4130 TOP FL400 STNR NC=

There is also a system that generates automatic lightning warnings that are sent to airport. There are three alert levels, depending on the distance to the airport from the nearest detected lightning strike, along with an all clear message. A pre-alert warning is issued when the strike is detected within a 25-km radius of the airport. An alert warning is issued when the detection takes place within an 8 km radius, and the maximum alert occurs when lightning is detected within 5 km. The all clear message is issued when no strikes are detected in any of the above areas over a 10-minute period.

On the day of the accident, the first warning issued was a pre-alert at 14:22. Between 14:38 and 16:02 there were nine alerts, and from 15:24 to 15:54 nine maximum alerts were issued.

The all clear was given at 16:48.

Weather radar images

The figure below shows the radar returns from the plan position indicator (PPI) taken every 10 minutes between 14:10 and 15:10, and provide an idea of the progression and movement of the storms in the Barcelona area.

These PPI images show the reflectivities projected on a horizontal plane at radar level obtained during the radar’s sweep at its lowest elevation (0.5° above the horizontal). The reflectivity is directly related to the precipitation such that the returns indicate the areas where it is raining and the colors show the intensity.

As Figure 3 shows, during this period of time the projected reflectivity area grew in scale as it moved southeast. At 15:10, approximately five minutes before the aircraft landed, the reflectivity projection area had not yet reached the airport.

Figure 4 shows the weather radar image for 15:20, after the landing. By this time the reflectivity projection area was so close to the airport that it had practically reached it.

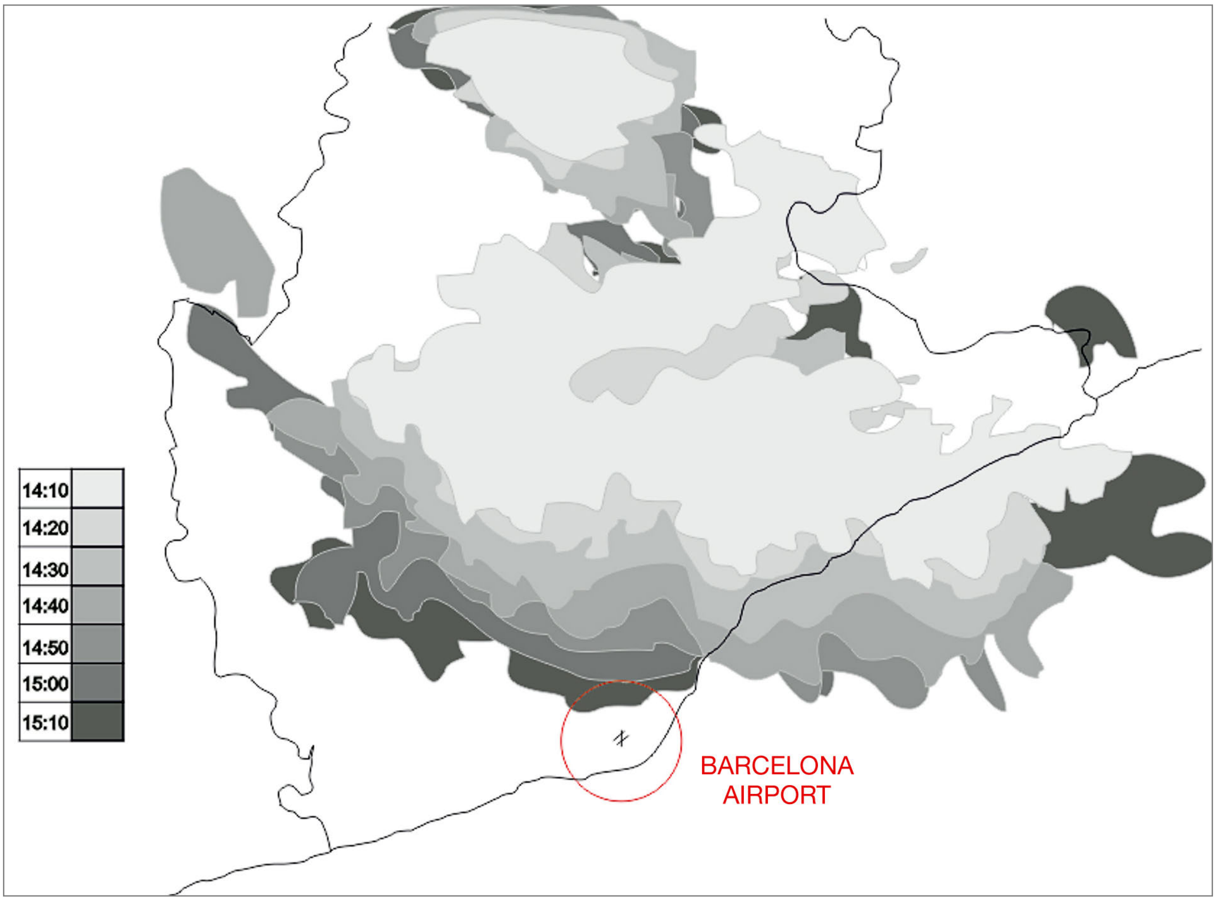


Figure 3. Sequence of weather radar images for the Barcelona Airport area

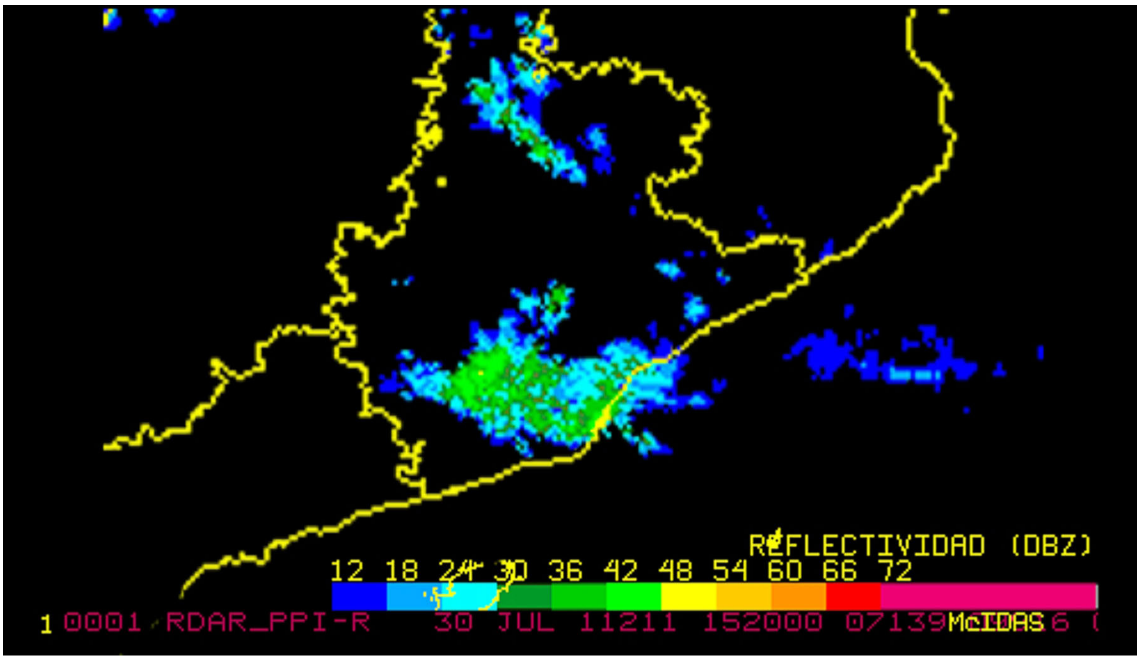


Figure 4. 15:20 UTC weather radar image

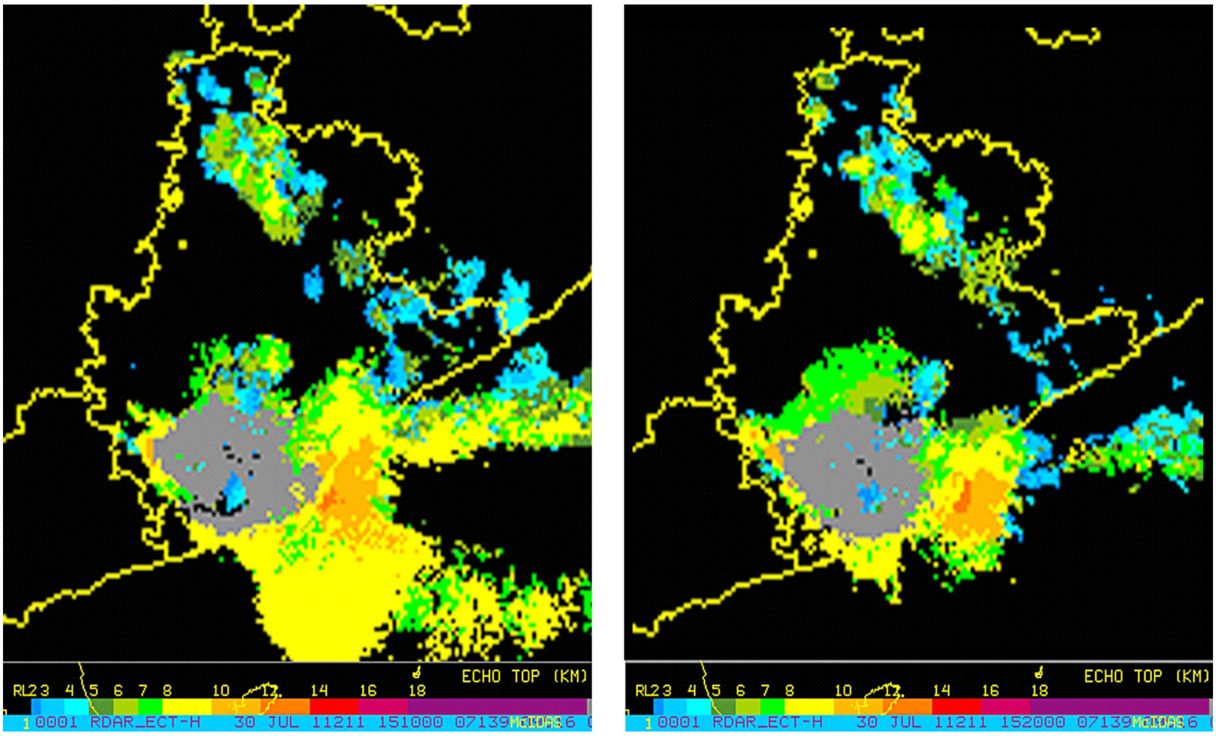


Figure 5. ECHO TOP weather radar images from 15:10 and 15:20 UTC

There are other weather radar images called ECHO TOP (Figure 5) that show the altitude of the cloud tops using a color code. The areas colored in gray are those for which there is no information.

As the above and below images show, at 15:10 UTC there were abundant clouds in the area of the Barcelona Airport. In the runway 07 approach area there were some fairly isolated orange patches within a large yellow area. The runway 25 approach, in contrast, was nearly entirely shown in brown/orange, indicating clouds with tops at altitudes of up to 14 km (46,000 ft).

Between 15:10 and 15:20 there was a notable decrease in the size of the colored patch around the runway 07 approach area, while the runway 25 approach remained practically unchanged.

Satellite images

Two types of satellite images are available: RGB and HVY. The former are colored images where cloudy areas shown in blue indicate the presence of very high cloud tops with ice formation. The latter are high-resolution visible satellite images where the pixels are tripled in order to improve the view. These show large vertical development convection clouds with very high tops.

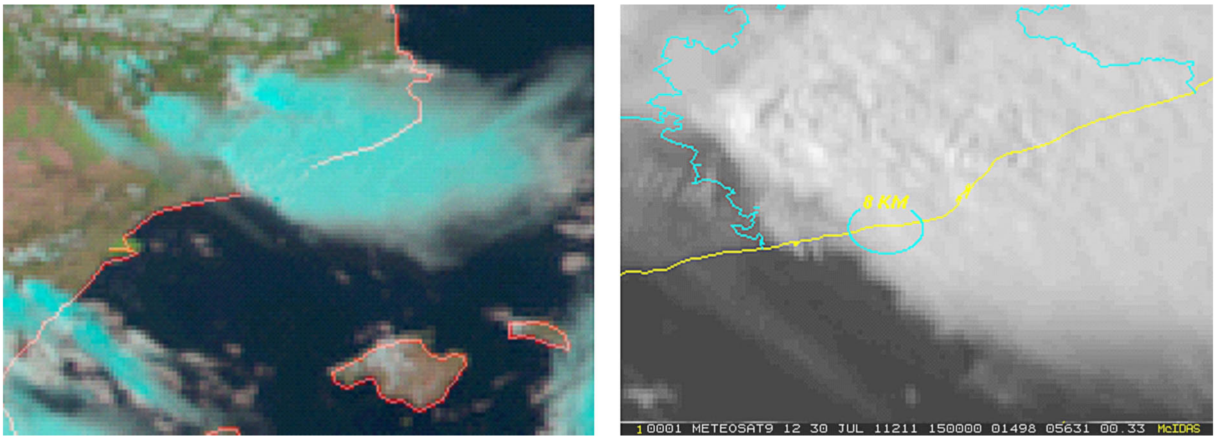


Figure 6. Satellite images: RGB (left) and HRV (right) from 15:00 UTC

Other meteorological records

The wind data recorded were analyzed, especially those for instantaneous wind (speed and direction), average wind speed and direction in 2-minute intervals, maximum 10-minute wind speed, as well as the altitudes of the first, second and third cloud layers, all for the time period spanning from 15:00:00 until 15:15:10.

Until 15:08:40, the wind was primarily from the south at approximately 10 kt.

From 15:08:50 on, the instantaneous wind speed started increasing gradually and it was primarily from the north. The highest value, 29 kt, was recorded at 15:12:30. The wind speed remained above 20 kt until 15:14:00, and was between 15 and 19 kt in the minute after that.

At around the time when the aircraft was in the cloud layer that forced the crew to climb (15:12:26), only a single cloud layer was detected, whose base remained at an altitude of between 2,000 and 3,350 ft.

1.7.3. *Meteorological information available in ATC stations*

There are basically two sources of information on storm cells available to ATC stations: information reported by aircraft crews flying under their control and visual observation.

Aerodrome controllers, who are physically located in the airport's control tower, obtain weather information from both of the aforementioned sources.

Approach controllers, who are typically located in control centers, obtain information from crews.

In this case, the crews of the aircraft that made approaches to runway 25R at the airport before the accident aircraft provided the final approach controller, who is in the control center, information on the position of the storms. Based on this, the controller knew that the storms were moving from the north toward the airport.

In this specific case, none of the crews on the preceding flights made any mention of the presence of a storm cell on the 25R extended runway centerline.

1.8. Aids to navigation

Not relevant.

1.9. Communications

1.9.1. *Communications with ANE 8313*

Investigators reviewed the communications between the aircraft and control stations on the final part of the flight, which in this case were five and belonged either to the control center or to the Barcelona control tower. Specifically, flight ANE 8313 made contact with sectors T3, T2, final 25R, TWR and GMC SS in Barcelona, in that order.

Sector T3

The initial contact with this control center sector was made at 15:01:39 UTC. The controller instructed the crew to descend to flight level 130.

At 15:04:59, the controller called the aircraft to instruct the crew to descend to FL80.

At 15:05:15 the controller once again called the aircraft to instruct the crew to turn left to heading 090.

At 15:07:05 the controller instructed the crew to fly straight to RULOS, and five seconds later told them to contact sector T2 on a new frequency, 121.15 MHz.

Sector T2

The crew of ANE 8313 called sector T2 at 15:07:18, that is, eight seconds after having been transferred.

The controller instructed them to descend to 4,000 ft, with 1,015 hPa (QNH), and eight seconds later told them to fly heading 045.

At 15:07:53 the controller instructed the crew to maintain 210 kt.

At 15:08:35 the controller told the crew to contact “final” on 119.10 MHz.

Final 25R

During the initial exchange with this station the controller reported radar contact and told them to fly heading 010.

At 15:08:56 the controller informed the crew that “I’ll no doubt get you in... four[3], on final... or even, if you accept visual, because it looks like the clouds are moving in over the localizer”. The crew replied “understood, no problem”.

At 15:09:09 the controller called the aircraft to instruct the crew to continue descending to 2300 ft, which the crew acknowledged.

At 15:10:18 ATC informed the crew that they could continue descending at their discretion, north heading.

A few seconds later the controller asked the crew if they could accept visual for 25 right, which they did.

As a result, at 15:10:33 the controller cleared them to make a visual approach base left to runway 25R, which the crew acknowledged.

Finally, at 15:13:08, the controller instructed the crew to contact the control tower on 118.10 MHz and thanked them for their cooperation.

Barcelona Airport control tower

At 15:13:29 the crew called the tower to report they were two miles out on final.

The controller cleared them to land on runway 25R and gave them information on the wind, which was from 350° at 24 kt, which the crew correctly acknowledged.

At 15:14:45 the controller called the aircraft to inform them “pass on 22.22 on your left”.

GMC SS

The crew called ground control at 15:15:11. The controller told them to taxi on taxiways E, J and QS to parking stand 296.

[3] Four refers to “mile 4”.

1.9.2. *Communications with the aircraft behind ANE 8313 in the sequence*

The communications between the crew of the aircraft that was flying behind the accident aircraft, an A-320, and the final-25R controller were also reviewed.

The crew of that aircraft called the controller on final at 15:12:00 to report that "we're too high. We're doing a 360 to our left to descend to 1,000 ft". The controller acknowledged the information, adding "roger".

At 15:14:15 the crew called the controller to report that in the event of a missed approach, they would have to go around to the left.

At 15:14:40 the controller called the aircraft to inform the crew that they had halted the takeoffs, meaning there would not be any problems turning left. The crew added that in the event of a go-around, they would proceed on a heading of approximately 180.

At 15:16:20 the controller transferred control of the aircraft to the control tower, instructing the pilot to contact that station on 118.10 MHz.

1.10. Aerodrome information

The Barcelona Airport has three runways, 02-20, 07R-25L and 07L-25R. The accident aircraft landed on this last one, the main characteristics of which are:

- Length: 3,352 m
- Width: 60 m
- Approach: precision CAT II/III, 690 m LIH
- PAPI (MEHT): 3° (13.86 m/45 ft)
- Lights:
  - Threshold: green
  - Touchdown zone: 900 m white
  - Runway centerline: 3,352 m: 2,452 m white + 600 m red and white + 300 m red
  - Runway edge: red

The AIP Spain has three procedures for landing on this runway: ILS, LOC and VOR, all of them instrument approaches.

On the date of the accident, the go-around maneuver published in the AIP Spain for the approach to runway 25R was:

> "Climb on R-246 BCN (runway heading) to 3000 ft and wait for ATC clearance."

1.11. Flight recorders

1.11.1. *Cockpit voice recorders (CVR)*

This event was reported to the CIAIAC on 5 August, several days after it occurred. Since the recorder remained in use and the aircraft was powered up several times in the interval, the recorder kept recording during that time, meaning the information from the accident flight was lost.

1.11.2. *Digital flight data recorder (DFDR)*

The aircraft was outfitted with a Fairchild FA2100 flight data recorder, P/N 2100-4043-00 and S/N: 000228102, which was downloaded at the CIAIAC's laboratory and verified to contain information on the accident flight.

The data from the final phase of the flight were analyzed in detail; specifically, the time interval between 15:09:09, when the controller called the aircraft to instruct the crew to continue descending to 2,300 ft, and 15:14:30, when the aircraft was on the runway.

In order to facilitate the study the event was divided into three phases: from the initial point (15:09:09) until 5 NM; from 5 NM out until the aircraft was at an altitude of 50 ft above the runway; and finally from there until 8 s after the landing gear made contact with the runway.

1st phase

At the start of this phase, 15:09:09, the aircraft was flying in the following conditions:

- Indicated airspeed (IAS): 210 kt.
- Altitude: 8,077 ft.
- Autopilot: engaged.
- N1 no. 1 engine: 31%
- N1 no. 2 engine: 33%
- Landing gear: retracted.
- Flaps: 0°

At 15:09:45 the crew deployed the air brakes and kept them deployed until 15:12:25. At that moment the aircraft's altitude was 7,022 ft and its IAS was 213 kt. N1 on the no. 1 and 2 engines was 31% and 32%, respectively.

Figure 7. Top view of the last 5 NM of the aircraft's flight path. The distances shown are from the threshold and measured based on the aircraft's actual flight path

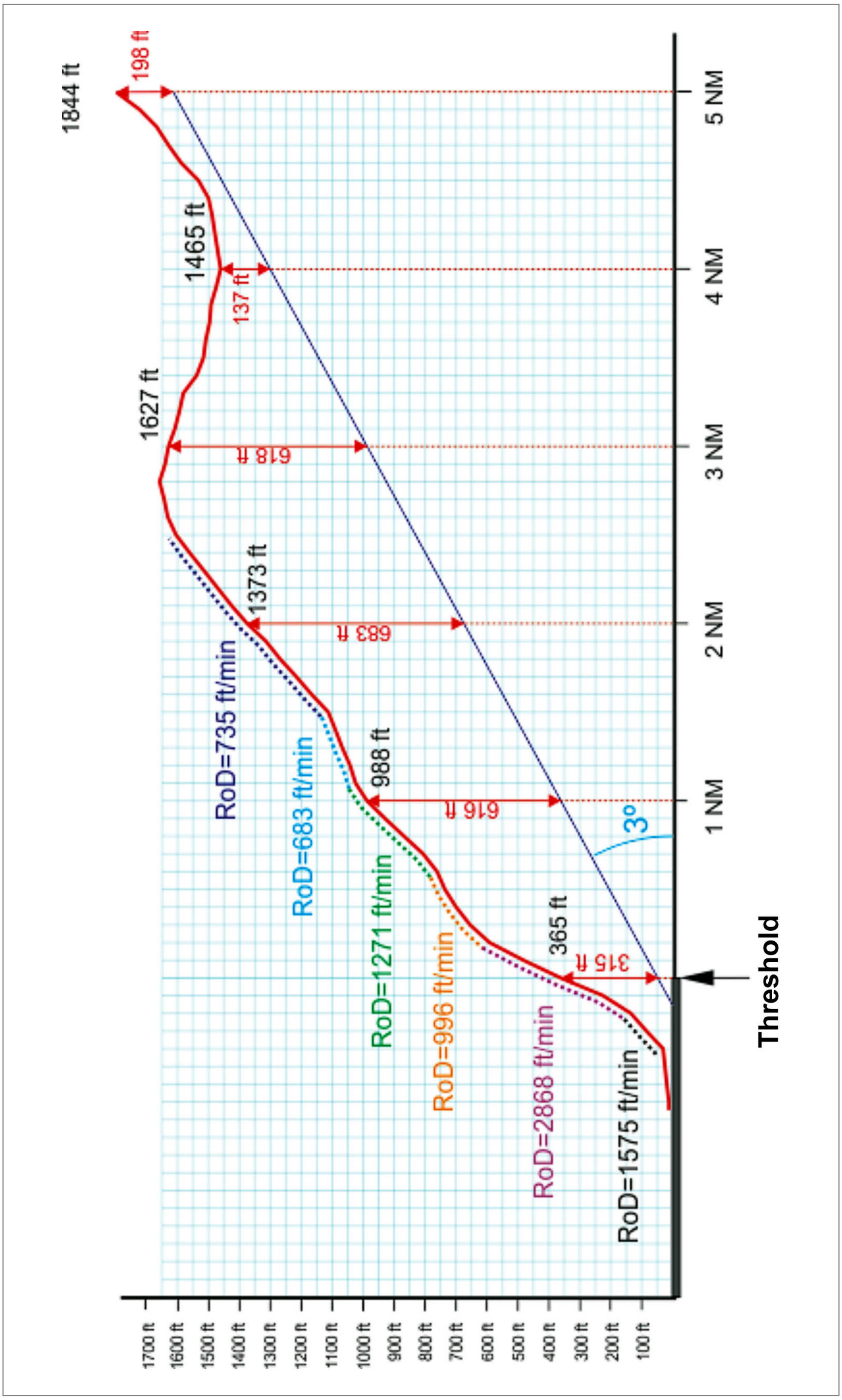


Figure 8. Altitude profile of the last 5 NM of the aircraft's flight path. The descent rate is shown for each segment (color coded) along with the excess altitude above the standard glide slope

At the instant when the controller called the crew to instruct them to descend at their discretion on a north heading (15:10:18), the aircraft's parameters were:

- Indicated airspeed (IAS): 214 kt.
- Altitude: 5,844 ft.
- Autopilot: engaged.
- N1 no. 1 engine: 30%
- N1 no. 2 engine: 32%
- Air brakes: 50° (deployed)
- Landing gear: retracted.
- Flaps: 0°

The landing gear was lowered at 15:10:49, at which time the aircraft's IAS was 209 kt and its altitude 4,443 ft.

At 15:11:22 the flaps were extended to 20° and at 15:12:07 to 45°. The reference speed, Vref, with flaps 45 for the weight of the aircraft was 133 kt. At that point the aircraft was 5.65 NM[4] away from the runway 25R threshold.

When 5 NM away from the threshold the aircraft was already in a landing configuration at an altitude of 1,844 ft and IAS of 145 kt. The autopilot was engaged. The aircraft was 198 ft above the theoretical 3° approach glide slope to the runway (see Figure 8).

2nd phase

Between the 5 NM and 4.6 NM points, the aircraft descended normally or even higher than the theoretical descent rate for the 3° glide slope, such that its excess altitude decreased. Between 4.6 NM and 4 NM, it continued descending but at a lower angle. By 4 NM its excess altitude had fallen to 137 ft.

The autopilot was disengaged at 15:12:25.

The air brakes were retracted at 15:12:26, just before reaching the 4 NM point at an altitude of 1,520 ft.

Inside of 4 NM, the aircraft started to climb, which it did until the 2.8 NM point, by which time its altitude was 1,700 ft and its excess altitude above the theoretical 3° glide slope was 775 ft. Its IAS was 132 kt.

[4] The distances from the threshold are expressed based on the aircraft's actual flight path.

From this point until contact was made with the runway, the aircraft was constantly descending. The profile view (see Figure 8) shows several segments with fairly uniform descent rates. These segments are labeled in the figure, along with the calculated descent rate maintained in each.

In the first four segments the average descent rates were moderate, with values of 735, 683, 1271 and 996 ft/min. The angle of descent was slightly in excess of the theoretical 3°. At the end of the last segment the aircraft was 0.2 NM away from the threshold at an altitude of 600 ft.

Practically coinciding with the start of the next segment, the air brakes were extended. The descent rate increased notably (2,862 ft/min on average). Two seconds after the extension of the air brakes the EGPWS started to issue warnings that persisted for the next 13 seconds until the aircraft reached the radio altitude (see footnote 1); from that point these alerts are inhibited by design.

Although the times when the EGPWS alerts were issued are recorded on the FDR, the type of alert is not.

Figure 9 shows the design criteria for the EGPWS mode 1 alerts (excessive descent rate), which are generated based on the (barometric) descent rate and the radio altitude. The graph shows two areas labeled A and B. If the aircraft's flight conditions correspond to area A, the EGPWS issues a "sink rate" warning, and if it is in Area B it will signal "whoop whoop pull up".

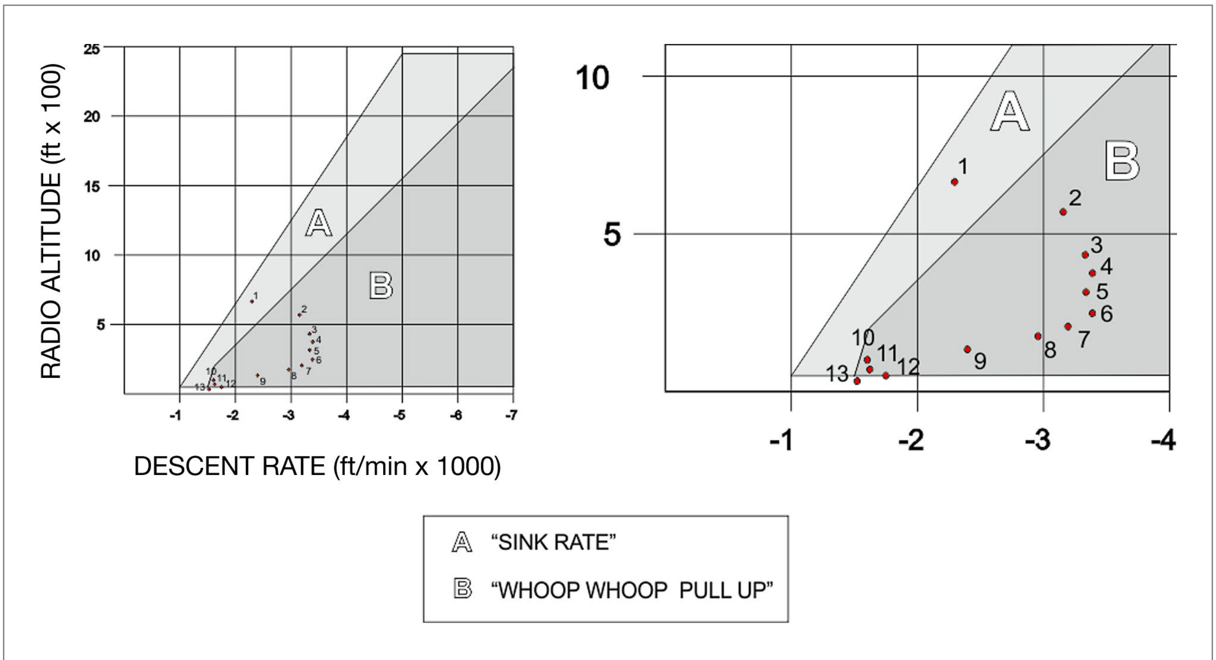


Figure 9. Graph of the mode 1 EGPWS alerts (left) and close-up of same graph (right)

Also shown on this figure are the points defined by the parameter pair of descent rate and radio altitude for the 13 seconds during which the EGPWS was issuing alerts. Based on this, the initial alert should have been a "sink rate" warning and the remaining twelve "whoop whoop pull up".

The aircraft flew over the runway 25R threshold at an altitude of 365 ft, which is 315 ft above the theoretical 3° glide slope.

Once over the runway and 0.125 NM past the threshold, the air brakes were retracted, though they were again extended one second later, remaining in that position until well after the aircraft had landed.

On this point it should be noted that the lift dumping system, of which the air brakes are a part, was activated after the second contact between the airplane and the runway. Thus, the fact that the air brakes remained extended after landing is consistent with the activation of this system. Since the position of the air brake lever is not recorded, it is impossible to determine when it was moved to the spoilers retracted position.

This segment ended 0.2 NM past the threshold toward the runway.

The next and final segment shown in Figure 8 encompasses the next 0.2 NM, that is, 0.4 NM over the runway. The average descent rate was more gradual than in the previous segment, its average value being 1,575 ft/min. By the end of this segment the aircraft still had not contacted the runway.

In addition to the trend in the parameters presented above, it is also worthwhile to consider how other parameters trended during this phase. As the graph in Figure 9 shows, the engines were at flight idle throughout. As regards roll and pitch motions, there was a clearly predominant tendency to roll left, the maximum value of which reached 42° just as the localizer was intercepted. The pitch angle reached a maximum value of 10° down.

3rd phase

The graph in Figure 10 provides a representation of the values of various parameters (EGPWS warnings, weight on wheels of the right main gear leg, vertical acceleration, N1 for both engines, air brakes, roll angle, pitch angle, IAS and radio altitude). It starts at time 15:13:39 and at an approximate altitude of 1000 ft, which almost coincides with the start of the second segment (light blue color) shown in Figure 8, and continues until 15:14:31, that is, eight seconds after the aircraft's initial contact with the runway.

This third phase spanned nineteen seconds, from 15:14:20, corresponding to a radio altitude of 50 ft, until 15:14:39, with the airplane already on the runway.

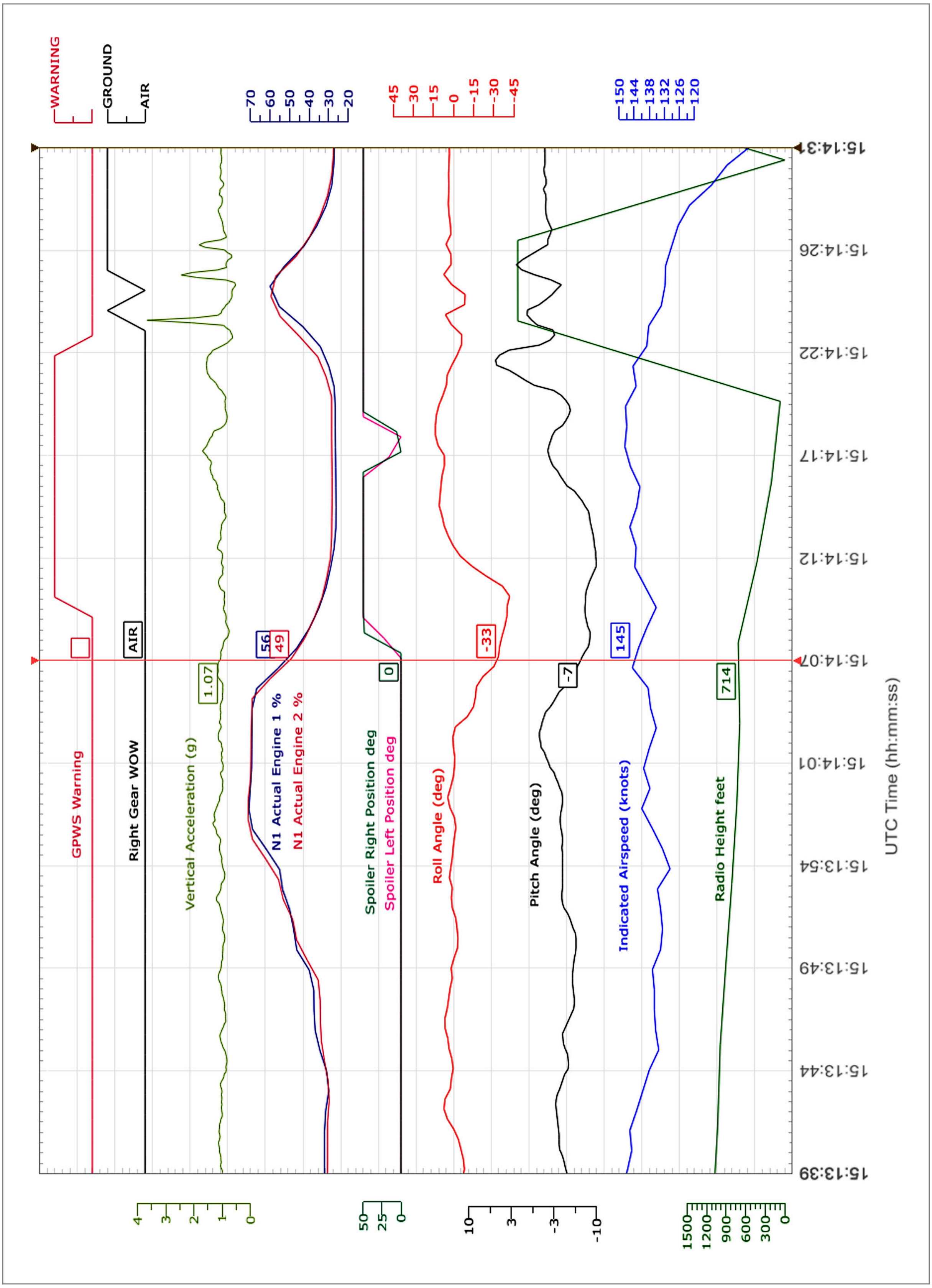


Figure 10. Trend in various parameters during the final approach phase

At the start of this 3rd phase the aircraft was at an 11° right roll angle and a 6° nose down angle. Its IAS was 144 kt. Both engines were at flight idle.

One second later the roll angle had dropped to 5° and the pitch angle had changed sign, meaning the aircraft had gone from a nose down to a nose up attitude. This signaled the start of the flare by the PF. The N1 value on both engines had increased.

The highest nose up angle was reached in the next second, 6°, and the IAS fell by 4 kt to 139 kt. The value of N1 continued to increase.

Then, a second later, the nose and right main gear wheels contacted the ground at an IAS of 138 kt. During this second there were several high vertical acceleration values recorded, the maximum being 3.66 g's. The air brakes were extended but the ground spoilers were not. The N1 values for the left and right engines were 43% and 55%, respectively.

The aircraft bounced and was in "air" mode in the next second, meaning none of its landing gear legs was supporting any weight.

At 15:14:25 UTC the right main gear leg again contacted the runway, resulting once more in high vertical acceleration values, the maximum this time being 2.45 g's. Neither of the two other gear legs contacted the ground. The ground spoilers extended. The two values recorded for the roll angle during this second were 1° and 7° to the right. The N1 values for the left and right engines were 60% and 57%, respectively, the highest recorded during this phase.

At 15:14:27 the other two gear legs, nose and left main, made contact. The maximum vertical acceleration value recorded during that instant was 1.82 g's. The IAS was 129 kt. The N1 values had decreased to 43% and 40% for the left and right engines, respectively.

The aircraft's speed started to decrease once all three gear legs were resting on the ground, and by 15:14:39, twelve seconds later, the IAS had dropped to 50 kt.

The reversers were not deployed, meaning reverse thrust was not used to slow the airplane.

1.12. Wreckage and impact information

Not applicable.

1.13. Medical and pathological information

Not applicable.

1.14. Fire

There was no fire in the aircraft or surrounding area.

1.15. Survival aspects

Not applicable.

1.16. Tests and research

1.16.1. *Captain's statement*

He had been on call that day and flew on a position flight to Barcelona to do the Barcelona-Badajoz-Barcelona route. He was based in Madrid and the first officer in Barcelona, so it was their first time flying together.

The accumulated delay in the schedule was due to the late rotation of the airplane from another route. He said that he had met the first officer early enough that they were able to prepare for the flight.

On the accident leg he was the PM[5] and the first officer was the PF. The flight was routine and had been planned with sufficient fuel that this would not be a factor.

As they neared Barcelona, ATC reported there were storms in the area, especially in Sabadell (northwest of the airfield) and provided them with an alternate arrival route that crossed the runway centerline extension (QMS) and took them south of the airport. It was not a standard arrival and it placed them shortly thereafter in a left downwind leg for runway 25R.

The approach briefing was normal for the anticipated situation. When the arrival route was changed, the shorter distance forced them to descend quickly and they were unable to update the briefing details.

Shortly after crossing abeam of the airfield, ATC informed them of storms ahead of their position and provided them with a vector that positioned them at a 90° angle to the final approach heading. He then asked the first officer if he could go in from that position, to which the first officer said yes, so he agreed to continue.

[5] The pilot who is not physically flying the airplane is no longer usually called the PNF, due to the passive connotation of this term. As a result of advancing trends in CRM, the PNF is now the PM (pilot monitoring), which is a way of inferring that the entire crew is responsible for the flight, and not just the PF. The PM monitors, guides and alerts the PF.

He stated that ATC urged them to make a sharper turn and go to visual. He regarded the proposal as benefiting them since it took them away from the storm. He also thought it would facilitate ATC's task by letting them route in additional traffic. The first officer had the runway in sight and they proceeded to intercept the localizer at 4 NM.

While executing the maneuver the first officer went above the clouds, which the captain thought proper, though he would have rather stayed below the clouds without losing visual contact.

As they intercepted the localizer they lost sight of the runway. The turn onto the final approach course was also too wide, meaning they were not lined up until they were just within 2 NM of the threshold, at which point, as they were exiting the clouds, they saw a magenta return on the radar at the opposite threshold, indicative of vertically developing clouds (Cb).

As they exited the clouds, the captain thought the standard missed approach to be unviable and that they did not have time to "negotiate" an alternative with ATC, since there were other airplanes on the downwind leg to their left. Going around to the left risked crossing their path or colliding with them, while to the right there was mountainous terrain. This led him to decide that the least risky option was to land.

The captain expressed feeling pressured by ATC to shorten the approach maneuver as much as possible, since they were told that the storms were quickly approaching the localizer. He stated that it was unusual for Approach Control to suggest a visual maneuver and that, in agreement with his first officer, they decided to accept given the urgency of the situation, believing themselves capable of executing the maneuver safely.

He noted that at no time were they informed of the location of the storm cells that prevented them from going around.

Unlike the other aircraft which made the approach afterward, their flight path, almost perpendicular to the final heading and which shortened the route they initially expected to take so as to intercept the localizer only a few miles away, meant that the weather radar was unable to provide them information on the storms until they were practically lined up on final. This deprived them of the time necessary to negotiate an alternative missed approach procedure.

Since they had been level for a while due to the presence of low clouds before seeing the runway, they now found themselves too high on final for the standard approach. Given the first officer's hesitation, he decided to take control.

On final approach, he was overwhelmed trying to control the airplane during the final 150 feet. He thinks he took control at an altitude of about 600 feet 0.5 NM away from the threshold and that he flew over it at about 300 feet.

The captain retarded the throttle to idle and extended the spoilers. He himself retracted them and justified re-deploying them as a reflex action, since he did not recall doing so voluntarily. He stated that he was not concerned by the remaining runway distance and that he might have been overwhelmed by the circumstances.

Since he had both hands busy, he instructed the first officer to increase thrust. The first officer did so but the delay meant that the engines increased power after they had touched down.

He felt the airplane sink on touchdown. He tried to flare but did not think it would work. He did not believe the engines would have spun up in time to halt the descent rate. They landed with a bounce and exited via the usual taxiway. He did not recall using reverse thrust during the landing run.

Once on the ground they did not notice anything unusual in the airplane's behavior, though they were perfectly aware of the hard landing, reporting it to maintenance and noting it in the aircraft logbook.

While taxiing, two or three minutes after landing, it started to pour over the airport, presumably due to the storm cell they had observed.

The captain faulted ATC for informing them of the cumulonimbus to the east of the field but not giving them any information about the vertically developing cloud that had kept them from going around. It was not until he ran out of options that he realized he could not go around. He did not know if ATC is required to inform them of this situation, but he expressed his conviction that he would have never gone into the formations like those present on the go-around heading.

In his opinion, an approach cannot be started without an alternative missed approach if the standard one is blocked by CB's. He thought that ATC kept shortening their approach without keeping this in mind. He felt like they were being "shoe-horned" with no margin for error.

He thought that ATC should guarantee a go-around and that their forcing of the situation in order to move traffic in an out was unreasonable.

The information available during each approach phase was as expected and their decisions reasonable until they were on final, where their only option was to forego the norm while considering the potential risks, with the chance of colliding with aircraft on the downwind leg to the left or entering an area of red/magenta returns straight ahead. He finally opted to destabilize the approach and land. The captain still asks himself what else he could have done differently, but continues to see no other alternatives.

1.16.2. *First officer's statement*

For the last flights on that day's rotation he was assigned an on-call captain. He flew the Barcelona-Badajoz leg as the PM and the Badajoz-Barcelona leg as the PF.

As for the weather information available, the METAR had no significant information while the TAFOR mentioned the possibility of showers and cumulonimbus clouds. Also, though he did not recall the exact amount, he thought they had some extra fuel.

Takeoff performance was adequate and the entire flight, including the cruise phase, was routine.

When they were transferred to Barcelona route control, they were assigned an arrival via Sabadell to runway 25R. By then they could already make out the distant cloud formations on the radar.

Their idea regarding the weather situation at that time was that the storms were north of the airport.

Subsequently, and to avoid the storms, ATC suggested that they approach the airfield from the south, which caused their workload to increase considerably. He was at the controls while the captain entered the new information into the FMS.

Once in contact with approach control, they went direct to RULOS. They noticed a storm coming in from the east of the airfield which made them expedite their descent. When near RULOS they could clearly make out the storm some 10-15 NM away from their location on the radar. The runway, though, was clear of clouds while they flew the left downwind leg to 25R.

The ATIS only mentioned scattered (Sc) clouds at 2,500 ft and visibility in excess of 10 km, giving no information on storms or "TEMPO" type codes.

Final Approach Control suggested they proceed to 5 NM and make a visual approach. Since the storm was between 10 and 8 NM away from the airport, it seemed feasible, so they configured the airplane early such by the base legs the flaps were already at 45°.

On the base leg they descended to 1,500 ft. The storm, meanwhile, had moved very rapidly and there was already a low cloud layer. He then realized he would lose visual contact with the runway, so he decided to intercept the localizer. His intention was to intercept it at 5 NM, but there was considerable storm activity to his right, which caused him to intercept the localizer at 3 NM. He held his altitude until they were established on the localizer.

During the intercept maneuver the first officer was watching his instruments while the captain observed outside references. That is why the captain was the first to see the runway. When he saw it he hesitated, since he could not attempt the landing without destabilizing the approach. When they lined up with the runway, they were able to see another storm at the opposite threshold that appeared red-magenta on radar and that would hamper a go-around. He noted that they had noticed the clouds in the go-around area while on the base leg, but it was not until they lined up on final that they saw the severity of the radar return. Moreover, runway 25L remained in use for takeoffs.

It was during that moment of hesitation that the captain said "my control!" and became the PF and the first officer the PM. The captain deployed the spoilers and the EGPWS issued an excessive sink rate warning. The first officer warned him saying "careful!" and retracted the spoilers, though he was later surprised to learn they were still extended. He did not know when they were extended again. As they crossed the 25R threshold he again warned the captain about the high descent rate, though he did not understand why it was so high. He did not make the standard stabilization call outs (vital items), since he thought that once the decision to land was made under those conditions, the call outs were not necessary.

He stated that he was aware of the EGPWS warnings and their implications but did not claim to have ignored them. They heard the "Sink rate" and "Pull up" warnings.

The captain asked him to advance the throttles and he did, though it did not prevent the hard landing. The subsequent braking was normal and they exited the runway via R5, which is the taxiway that is normally used. The landing run, thus, was not very long despite the bounce.

1.16.3. *Statement from the flight attendant*

She stated that the flight had been uneventful and that on approach she was instructed to prepare the cabin for landing. She secured the cabin and reported this to the crew using the FLT.

She then sat in her seat in the brace position (head slightly back, legs slightly separated and hands underneath the thighs). About two minutes later she saw the airplane darken to the point that it looked like it was nighttime and she saw lightning. She suddenly felt a hard impact on the floor that made her neck turn left. The airplane then rose again. She changed her brace position by crossing her arms, which she felt was more secure. The airplane fell again and hit the runway, though this time it did not rebound. The airplane continued moving down the runway and shortly afterwards braked sharply.

When the grabbed the intercom to make the taxi announcement, she realized that her neck hurt when she turned it.

When the seat belt sign was turned off, she called the crew to inform them of her condition. Once the passengers were disembarked, the pilots took her to receive medical attention.

1.17. Organizational and management information

1.17.1. *Information in the Manuals*

1.17.1.1. Stabilized approach

EU OPS 1.400 states:

> Approach and landing conditions
>
> Before commencing an approach to land, the commander must satisfy himself/herself that, according to the information available to him/her, the weather at the aerodrome and the condition of the runway intended to be used should not prevent a safe approach, landing or missed approach, having regard to the performance information contained in the Operations Manual.

In keeping with this regulation the operator, in Part A of its Operations Manual, Chapter 8 "Operating Procedures", Chapter Q "Descent, hold and approach", states:

> "It is the Captain's responsibility, after assessing the information available, whether to start the approach and what type to use".

This same chapter also defines the general alignment and stabilization criteria for a final approach as well as for go-arounds. It states:

> "Q.6.2.5. Alignment and stabilization on final approach
>
> So as to ensure a safe final approach and landing, it is necessary to maintain:
>
> - A stabilized approach
> - The required configuration
> - The airplane aligned with the runway.
>
> The airplane is considered to be stabilized when all of the following conditions exist:
>
> - Airplane on the correct flight path (aligned with the runway)
> - Speed between Vref and Vref+20
> - Sink rate under 1,000 feet per minute

- ILS within one dot of the LOC/GS
- Briefings and checklists completed
- Proper landing configuration (gear and flaps) as per the corresponding OM(B).

An airplane is considered to be aligned with the runway when:

- It is within ± 5° of the runway centerline on non-precision approaches.
- It is within ± 1 dot of the localizer indicator on precision approaches.

If during an instrument approach without visual references (IMC) the airplane is NOT stabilized at 1,000 feet above the touchdown zone elevation (TDZE), THE AIRPLANE MUST EXECUTE A GO AROUND.

If during an instrument approach with visual references (VMC) or a visual approach the airplane is NOT stabilized at 500 feet above the touchdown zone elevation (TDZE), THE AIRPLANE MUST EXECUTE A GO AROUND.

In any case, the wings must be level by 300 feet above the TDZE.

If due to causes beyond the crew's control (ATC requirements, an emergency or any other unforeseen circumstance) any of the stabilized approach parameters indicated above cannot be maintained, the Captain must give a special briefing so as to ensure the safe completion of the approach".

More specifically, point 1.2.4 of the CRJ200/900 Pilot Reference Manual (B Operations Manual), "Approach & Missed Approach", specifies the following:

"All approach maneuvers must comply with the stabilized approach criteria. In other words:

- The airplane is on the correct flight path.
- Only small changes in heading/pitch are required to maintain the correct flight path.
- Sink rate no greater than 1,000 feet per minute.
- The aircraft speed is not more than Vref+20 and not less than Vref.
- On all approaches the aircraft must be established on final in the landing configuration and stabilized at a minimum altitude of 500 ft RA.

If not a missed approach must be initiated.

At 500 ft RA the PM must check the following:

- Gear down and locked
- Flaps in landing configuration

- Reverse thrust armed
- Approach satisfies stabilized approach criteria.

If all of the above apply, the PM will say "VITAL ITEMS CHECKED". If not he must say "GO AROUND". The PF will only continue with the approach if he hears "VITAL ITEMS CHECKED". If the PM does not make this call out on reaching 500 ft RA or says "GO AROUND", the PF MUST IMMEDIATELY GO AROUND".

THE "VITAL ITEMS" CHECK IS CONSIDERED A MEMORY ACTION FOR ALL APPROACHES

This same point in the PRM states the following regarding visual approaches:

"Do not descend unless visual contact is established and maintained with the ground and/or lights".

Concerning accepting VFR clearances, point 8.3.1.A of the operator's Operations Manual A, "IFR and VFR flights", states:

"... VMC clearances intended to maintain own separation shall be requested or accepted only for a limited climb, descent or approach segment as long as the following are complied with...

- Meteorological conditions are such that the corresponding segment can be flown continuously in VMC.

... The above in no way forbids the execution of visual approaches properly authorized by ATC as long as Captain has the airport in sight and is familiar with it and its surroundings".

1.17.1.2. Go around

In terms of the conditions for executing a go-around, the operator's OM A states:

"Q.6.2.8. Go around

This procedure is to be followed if the approach cannot be continued (ICAO Doc. 8168). This procedure is to be initiated:

- When any of the ground or onboard equipment required for the type of approach in progress fails and it is not possible to continue using another

approach.
- If there is excessive wind shear on short final or if there are significant changed in the airplane's attitude.
- If on reaching the MDA/DH/DA, the pilot does not have the "required visual reference".
- When the landing is not expected to be completed within the TDZ.
- When the stabilization and alignment conditions specified in Chapter 8.3.0.Q.6.2.5 are not met.

The crew must be in the proper mindset in the sense that a go-around can be executed at any time, especially during the segment associated with the visual phase.

In its OM B (PRM), the operator states:

The flight crew shall go around in the following situations:

- If required by ATC.
- When the PF determines that the aircraft's position or attitude is unsafe with regard to the desired glide slope.
- The visual reference at the DH/MDA is not suitable for a safe landing. The landing cannot be made within the TDZ (touchdown zone).
- Any equipment required for the flight is inoperative (e.g. antiskid, flaps failure, etc.)
- Any of the ground equipment is inoperative.
- If the captain orders a go around.
- The PM shall initiate a go around if he does not get the "LANDING" or "CONTINUE" message after getting the "MINIMUMS" message.
- The PF shall initiate a go-around if on reaching 500 ft RA, the PM does not call out "VITAL ITEMS CHECKED".

1.17.1.3. Ground proximity detection

In terms of ground detection, EU OPS 1.395 specifies:

"When undue proximity to the ground is detected by any flight crew member or by a ground proximity warning system, the commander or the pilot to whom conduct of the flight has been delegated shall ensure that corrective action is initiated immediately to establish safe flight conditions."

In this regard the company provides ample instructions and recommended actions for the alerts issued by the EGPWS in both the OM A item 8.3.5 and in the PRM, 2.2.3 section H.

The information contained in the OM A includes an explanation of the different types of EGPWS alerts.

"C.1. ALERTS

The TAWS provides visual and audible alerts if it detects:

- Potentially dangerous terrain (Modes 1-4, TCF and TAD).
- Flight below the glide slope (Mode 5).
- A descent below predefined altitudes (Mode 6).

The following list identifies in order of priority the possible alerts by type and mode:

Alert	Warning	Caution	Advisory
"PULL UP"	1,2,TA		
"TERRAIN, TERRAIN"		2,TA	
"OBSTACLE, OBSTACLE"		TA	
"TERRAIN"		2	
"MINIMUMS,MINIMUMS"			6
"CAUTION TERRAIN"		TA	
"CAUTION OBSTACLE"		TA	
"TOO LOW TERRAIN"		4, TCF	
"TOO LOW GEAR or FLAPS"		4	
Altitude callouts			6
"SINK RATE"		1	
"DON'T SINK"		3	
"GLIDESLOPE"		5	
"BANK ANGLE"*			6

* On certain units

C.2. RECOMMENDED ACTIONS

In the event of a Caution Alert:

1. Stop the descent and climb to clear the alert. Analyze the instruments and information available to determine the most effective action.
2. Notify ATC of the situation if necessary.

In the event of a Warning Alert:

1. Actuate the throttle controls quickly and forcefully to maximize thrust. The PM must set the thrust and ensure that the TO/GA thrust and modes are activated.
2. If engaged, disconnect the autopilot and gradually increase the pitch angle quickly and forcefully to the stick shaker limits in order to obtain maximum climb performance.
3. Continue climbing until the alert clears and the safety of the flight is guaranteed.
4. Notify ATC of the situation.

NOTE: Climbing is the only action recommended unless the pilot, based on the available information and the visual conditions, determines that turning and climbing at the same time is the safest course of action. Navigation shall never be based solely on the information displayed on the monitor.

1.17.1.4. Use of reverse thrust

The "Before Landing" checklist contains the following actions:

BEFORE LANDING

CABIN SECURE	REPORTED	PF
FLIGHT ATTENDANT..	ADVISED	PF
CABIN SIGNS	BOTH ON	PF
THRUST REVERSERS...	**ARMED**	PF
LANDING GEAR	DOWN & GREEN	PF
FLAPS..	___° INDICATING	PF
APU / BLEEDS	AS REQUIRED	PF

The fourth item on the list requires arming the thrust reversers.

In Section 1.2.5 of its PRM, the operator requires crews when landing to use reverse thrusters during normal and maximum performance landings.

"A.1. NORMAL LANDING

Once the main gear touches down, the reverse thrusters can be set to idle. Lower the nose gear without delay and then apply brakes and reversers as required.

Air Nostrum's policy is to utilize idle reverse unless required for safety reasons or runway contamination. Never hesitate to use full reverse thrust if necessary".

1.17.1.5. Meteorology

In chapter 8.3.8 of its OM A, the operator includes information on flying in adverse and potentially dangerous weather conditions. Specifically:

> "A. STORMS
>
> Avoid flying through storm cells and areas of known or forecast heavy turbulence.
>
> Avoid flying through an active storm by selecting the proper altitude or flight level, changing course or flying around the area, even if this involves having to cover a greater distance or results in a refueling stopover.
>
> C. TURBULENCE FROM CB CLOUDS
>
> Assistance is to be requested from ATC to ensure that a storm is not crossed on approach. The approach will be delayed or the crew will deviate to the alternate before risking entering a storm during this phase or while landing.
>
> When a CB is producing precipitation, crews must bear in mind that it will be accompanied by strong downdrafts that extend laterally below the base, causing strong drafts and sudden changes in direction in low-level winds.
>
> This combined with flying at low speed and altitude can create a dangerous situation. As a result, extreme precautions will be taken during an approach, landing or take off in these conditions, especially if new storm cells are forming in the vicinity of the airport.
>
> Crews must bear in mind the possibility that going around could take the airplane into a storm located in the missed approach path".

Item 8.3.2 of the operator's OM A provides instructions for using the onboard radar to avoid storm cells.

> "A.6.1. Avoiding Storms
>
> When flying in IMC and when storm activity is forecast or expected, the radar is to be used to provide early warning of CB activity and to anticipate the corresponding evasive action... The pertinent clearance is to be requested from ATC to avoid it".

1.17.2. *Flight Safety Organization*

The operator's Flight Safety Organization is arranged as specified in the organization chart included in the OM A, which states that the FSO follows the model of separating the Quality and the Flight Safety Departments. At the organizational level, the FSO has the status of a department, whose head reports to the Operations Manager.

Air Nostrum operates two airplane fleets:

- ATR-72,
- CRJ, which includes the 200, 900 and 1,000 models.

The company uses a Flight Data Monitoring (FDM) program to identify, quantify and correct operational risks.

This program highlights non-standard, unusual or unsafe events that, in combination with their frequency and estimated severity level, uncovers trends that could affect operational flight safety. Areas are identified where measures to mitigate risks should be implemented. Continuous monitoring and data analysis are used to determine the effectiveness of the measures adopted.

Air Nostrum has an FDM program for all of its aircraft, including the CRJ200 which, due to its weight, it is not legally required to have. QARs are installed on six of the series 200 airplanes for analysis. The FDR data are sometimes used for those airplanes that do not have a QAR.

The software used is the AGS SAGEM, which is the most widely used by commercial operators.

Every week maintenance personnel gather the data and download it to the system. The FDM detects events as determined by the criteria defined by the operator. These events are arranged into three degrees of severity. When an event occurs with a certain frequency or a high severity, the flight data are analyzed and the flight modeled, which facilitates its study.

The operator is part of an FDM group with other Spanish airlines, the aim of which is to standardize parameters and exchange information in an effort to better utilize the system.

The FDM is physically housed in the Technical Flight Support Office and is available to all crew who are interested in monitoring their flights.

In very specific cases the crews are called in to talk about flights with abnormal characteristics.

The Training, CRM and Flight Safety departments work closely to organize the information and disseminate the lessons learned from any relevant incidents or accidents.

The annual training cycle begins in the second half of December. Courses are held on flight safety as well as CRM.

The syllabus for 2012 included the influence of human factors in the company's operations and analyzed different types of destabilized approaches and their causes. The EC-ITU accident was one of the events covered in these flight safety courses.

If any special instructions arise from an analysis of flight safety, these are applied to the fleet's procedures by means of a technical note or through inclusion in the PRM. Such was the case, for example, of the 20 kt maximum crosswind in Vigo or the unique features of operating in San Sebastian.

Every three months Flight Safety issues an Operational Safety Bulletin, a paper copy of which is distributed around the bases and an electronic copy of which is posted on the intranet.

The theme of the last number issued in the second half of 2012 was primarily "STOP destabilized approaches". It underscores the role of the F/O as a barrier to avoid entering an undesired situation and, if such is the case, to carry out the corrective action.

The FDM program yields various statistics on the events detected that consider aspects such as event types and frequencies: destabilized approaches versus go-arounds, trends, analyses by airport, etc.

Parameter	Condition	Duration
Gear	Down & locked	–
Flaps	_ 2°	Any movement
Thrust	_ 35% N1	_ 5 sec
Sink rate	_ 1,500 fpm	_ 3 sec
Max IAS	_ V ref + 30 kts	_ 3 sec
Min IAS	_ V ref	_ 3 sec
Above GS	_ 1 dot	_ 5 sec
Below GS	_ 1 dot	_ 5 sec
Localizer deviation	_ 1 dot	_ 5 sec

Unstable approach criteria below 500 feet

Aviation Safety Information Analysis and Sharing Program (ASIAS)

Figure 11. Reportable FDM deviations as per ASIAS

In this regard, and as shown by the above table, studies are conducted internationally by working groups so as to standardize the types of events that are regarded as deviations and merit further analysis. Specifically, the ASIAS is a program spearheaded by the FAA that provides for the exchange of information in an effort to promote constant improvement in aviation safety.

The training criteria are standardized based on the analysis of these statistics.

For example, the most troublesome airports were noted to be San Sebastian and Pamplona, which led to operational procedures being designed and trained on to reduce this impact.

The safety indicators and statistics on stabilized approaches and EGPWS alerts are sent to the AESA as requested by this agency.

The Training Department, in turn, provided enhanced simulator training on instability and on the importance of call outs, especially the vital items that indicate that conditions are met for safely performing a landing.

This year's theme in the CRM courses is Situational Awareness, with the topic in 2011 having been Decision Making.

The findings and topics of interest to be discussed are decided on jointly with the human factors group and with the instructors.

In light of the problem detected regarding the preservation of flight recorder data, especially CVR data, the Operator was contacted to learn of the measures taken in this regard.

Despite the importance to investigations of having the voice and data recorders available, it was noted that no Spanish company specifically addresses in its procedures the need or the method to preserve CVR data.

The operator dealt with this issue at its latest Safety Committee, the minutes of which reflect the need to generate such a procedure and include it in its Operations Manual. The topic will be addressed at the following Procedures Committee. The possibility of including the Maintenance Department as the recipient of the procedure to back up the flight crew in the event of an oversight is being considered.

1.18. Additional information

1.18.1. *Radar information*

While the radar information available can be used to determine the flight path taken by the aircraft during the approach and landing, the data used by the system regarding the aircraft's altitude are not very accurate, since this information is transmitted by the aircraft itself but rounded off to the nearest hundred feet.

The flight data recorder, on the other hand, though it does not contain information about the aircraft's geographic location, does provide precise data on the barometric altitude.

Therefore, so as to obtain complete data on the aircraft's spatial position, investigators opted to synchronize the radar and FDR times by using the ATC communications. Once synchronized, the latitude and longitude information at any given moment can be obtained from the radar data and FDR altitude.

This information was then used to make Figure 7, which shows a top and side view of the aircraft's flight path.

Figure 12 also shows a reproduction of the radar screen for time 15:13:37, which reveals the location of the accident aircraft (red label) as well as of the remaining aircraft that were flying in the vicinity of the airport.

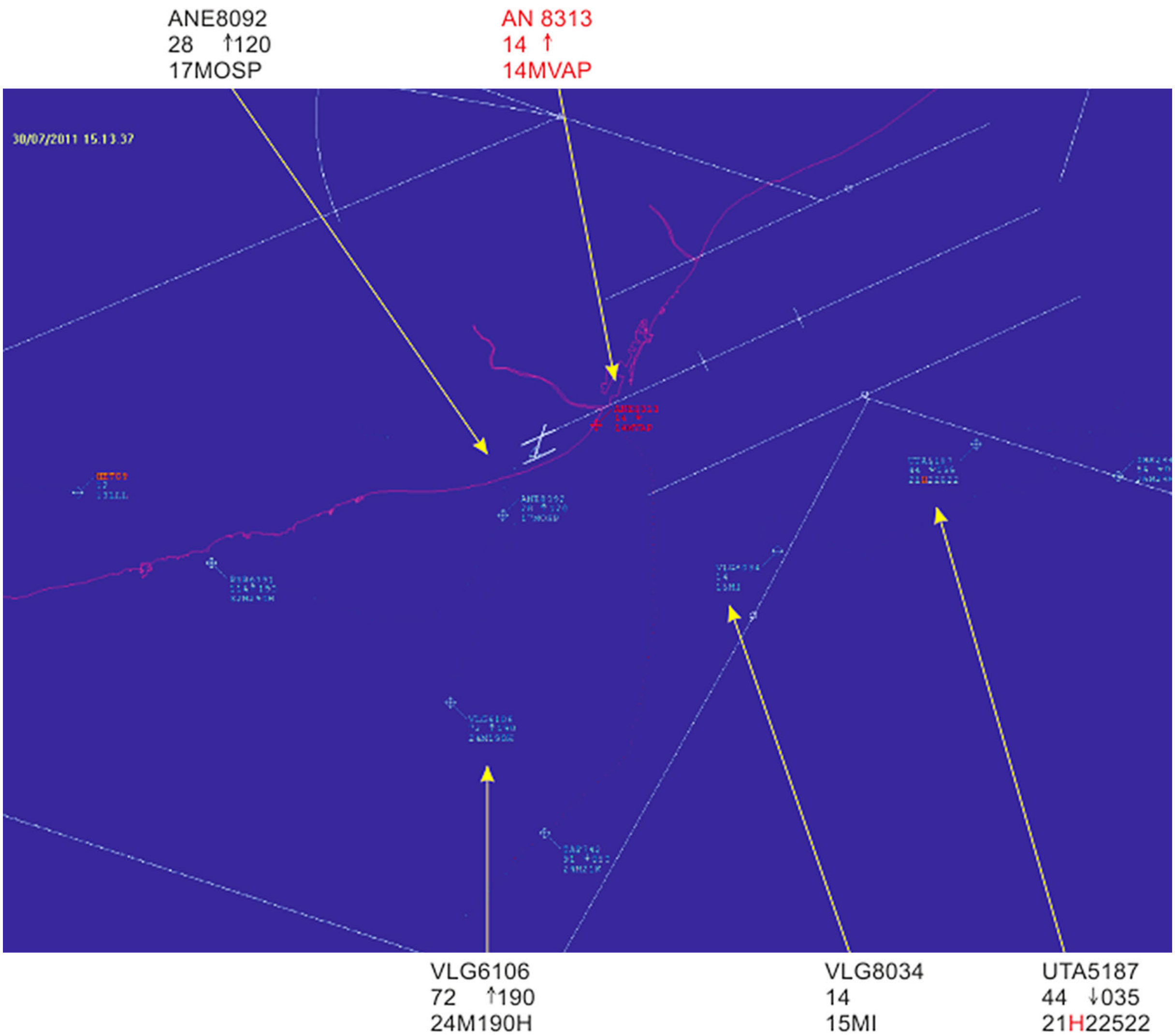


Figure 12. Radar display showing the radar trace of ANE 8313 (five labels have been amplified for a better visualization)

Of these, only four, the data for which are shown below, could be regarded as being near the accident aircraft.

Aircraft with call sign ANE 8092. Had taken off from runway 25L and at the time was at an altitude of 2,800 ft and climbing away from the airport to FL120.

Aircraft with call sign VLG 6106. It had taken off from runway 25L before the above aircraft and was at an altitude of 7,200 ft and climbing away from the airport to FL190.

Aircraft with call sign VLG 8034. This aircraft was behind the accident aircraft in the landing sequence. It was making a 360° turn at 1,400 ft southeast of the airport.

Aircraft with call sign UTA 5187. This airplane was behind VLG 8034 in the landing sequence and was at 4,400 ft east of the airport and descending to 3,500 ft.

Though it does not appear in the radar image on Figure 12, it is convenient to mention also aircraft with call sign JKK 2851. It was the last one to take off from Barcelona during this period. It started its takeoff run at 15:15:45, that is, around 1:20 minutes after the landing of ANE 8313.

1.18.1.1. Radar information on the aircraft behind EC-ITU in the landing sequence

At 15:12:40 the reproduction of the radar trace shows that the aircraft, which at the time was at an altitude of 1,600 ft and which was behind aircraft EC-ITU in the landing sequence, started to make a turn to the left.

At 15:15:27 the aircraft completed a 360° turn. At that time its altitude was 1,300 ft.

A little over two minutes later, the aircraft was over the runway centerline extension at an altitude of 800 ft.

In the seconds that followed the aircraft deviated to its right and kept doing so until, at 15:18:16, it went around, turning left and continuing to climb.

The aircraft behind it also went around and, like the airplane preceding it, also turned left.

Following this, the runway in use was changed, with the first aircraft landing on runway 07L at 15:29:30.

The last aircraft that landed on runway 25R, then, was ANE 8313 at 15:14:23. The next landing was on 07L at 15:29:30, meaning that in the 15 minute interval in between

there were no landings made.
The two aircraft, call signs VLG 8034 and UTA 5187, in the landing sequence behind the accident aircraft went around and both did so turning left, that is, neither adhered to the standard missed approach procedure.

1.18.2. *Regulations*

On 25/10/2012 it was published in the Official Journal of the European Union the Commission Regulation (EU) n° 965/2012, dated 5 October 2012, which establishes technical requirements and administrative procedures concerning aerial operations according to Regulation (EC) n° 216/2008 of the European Parliament and the Council.

Part CAT.GEN.MPA.195 of Regulation 965/2012 contains provisions which address the conservation, preservation and use of the recordings of flight recorders.

Letter a) of this section states: "Following an accident or an incident that is subject to mandatory reporting, the operator of an aircraft shall preserve the original recorded data for a period of 60 days unless otherwise directed by the investigating authority."

Also, on part ORO.MLR.100 of this Regulation they are established the requirements concerning the content of the operations manuals, among them the preservation of the flight recorders.

An acceptable means of compliance appears on AMC3.ORO.MLR.100, indicating that the OM should contain procedures for the preservation of recordings following a reportable event.

1.19. Useful or effective investigation techniques

Not applicable.

2. ANALYSIS

2.1. Meteorological situation

The weather reports and forecasts for the destination airport available to the crew when their flight was dispatched called for a 30% chance that visibility would be temporarily reduced due to precipitation and the presence of vertically developing storm clouds (cumulonimbus).

Barcelona was under visual atmospheric conditions when the aircraft took off from Badajoz.

As the METAR reveals, the weather situation at the Barcelona Airport did not undergo any significant changes until 15:00, by which time the METAR mentioned the presence of cumulonimbus with storms and rain showers.

As for the weather forecast, the TAF for the airport gave a low probability (30%) that vertically developing clouds resulting in storms would form. And while the fourth SIGMET message gave information on the presence of storms, it stated that they had been seen well south of the airport (between the Ebro Delta and the Cape of La Nao) and moving east, which made it unlikely that they would affect the aircraft during any portion of its flight.

The weather conditions encountered by the crew in the area of Catalonia were considerably worse than those forecasted. They even affected their arrival route, which was changed at ATC's suggestion.

The crew commented on the lack of information from ATC regarding the weather conditions in the missed approach maneuvering area (situated beyond the runway 07R threshold). Regarding this detail it should be noted that, as indicated in Section 1.6.3, controllers have limited weather information and their main source of information is the reports provided to them by crews. As a result they do not have detailed knowledge of the weather situation in the area under their control.

Despite having a large amount of data and images from weather radar, satellites and ground stations, an in-depth analysis of all the weather information contained in Section 1.6.2 does not clearly reveal the presence of vertically developing clouds in the missed approach area. Their presence, however, is indicated by the actions of the crews of the two aircraft behind the accident aircraft in the landing sequence and that went around and turned left.

In this regard it should be noted that weather radars scan at different altitudes and do not cover the entire vertical range. The fact that there were no returns in a given area does not mean there was no activity at other elevations.

In contrast, the weather radars typically used on airplanes offer the advantage of only having to conduct selective scans of the area of interest to crews. This fact could result in many crews thinking that ground facilities can provide weather information on the entire air space that is considerably more accurate and reliable than is actually the case.

From the preceding it may be concluded that even if ATC services had access to full weather information, they could not be completely sure of the weather conditions present in any given area at a specific time.

The investigation into this accident has underscored the lack of knowledge present in some aircraft crews regarding the weather information available to controllers. This could lead many crews to believe that controllers have exact knowledge of weather conditions. It could even result in the extreme assumption, as happened in this event, that if ATC does not report a significant weather phenomenon, it must not be present.

2.2. Analysis of the operation

On 30 July 2011, a Bombardier Canadair CL-600-2B19 (CRJ200) aircraft, registration EC-ITU, operated by Air nostrum, was on scheduled passenger flight ANE 8313 between the airports of Badajoz and Barcelona.

The captain had been on call and went on duty at 06:55 in Madrid, where he made a positioning flight to Barcelona.

The first officer went on duty at 04:25, this flight being the fifth that was scheduled for that day. It was the first time these two crewmembers had flown together since the captain was based in Madrid and the first officer in Barcelona.

Both the flight crew and the flight attendant were qualified and had valid licenses and ratings, in keeping with applicable civil aviation regulations in Spain and with the operator’s instructions and procedures.

They took off from Badajoz with 250 kg of fuel over the amount required in the operational flight plan, which listed Reus as the alternate airport.

The first officer was the pilot flying and the captain was the pilot monitoring. The takeoff, climb and cruise phases were routine.

The crew had planned to conduct the descent phase via Sabadell, north of the airport, but the controller suggested altering the route and entering via RULOS to the south, since traffic arriving from the north was diverting due to the presence of storm formations.

According to the captain's statement, the change in the arrival procedure and the modification to the planned approach maneuver upset the plans made during the approach briefing. The urgency of the situation kept them from holding a new briefing.

On reaching RULOS they were instructed to reduce their speed to 210 kt, so the crew started to decelerate and prepared to configure the aircraft for approach by extending the air brakes.

Once past RULOS, the approach controller informed them that he was directing them to the 4 NM point so as to expedite their landing, since the clouds were moving in on the localizer. He gave them vectors to intercept the localizer.

From an analysis of the communications, it is not evident that they received an explicit instruction to shorten the maneuver.

Later, specifically at 15:10:33, the controller asked the crew if they would accept a visual approach. On receiving an affirmative reply, he cleared them to conduct a visual approach to runway 25R.

After that point, once on visual approach, the controller no longer provides radar vectors or other instructions on the flight path the aircraft should take. The route to follow to line up with the runway and the altitudes to maintain are left to the crew's discretion. In this regard, it is possible that the information on how the vertically developing clouds were hampering the approach via the runway 25R localizer could have prompted the crew to try to hasten the approach as much as possible.

Until that point the aircraft had been flying on the course provided by ATC to intercept the localizer at the 4 NM point. But from then on the crew turned left on to a heading that would have them intercept the localizer on short final.

They lowered the landing gear before extending the flaps, thus hoping to add more drag to aid the already deployed spoilers in reducing their speed, so they could achieve the landing configuration as quickly as possible.

As they reached the limit speed for extending the flaps, they configured the airplane accordingly. They were in a landing configuration more than 5 NM away from the runway threshold while the aircraft was still over the sea to the SE of the airport on a north heading, at an altitude of 2,044 ft and an IAS of 152 kt.

The crew then took manual control of the aircraft by disengaging the autopilot and retracting the air brakes.

Their descent profile was slightly in excess of the theoretical 3° slope, regarded as ideal.

Until this point the approach and the landing could have been carried out in keeping with the “stabilized approach” criteria.

Within 4 NM they encountered a layer of low clouds that would have made it impossible to continue the approach under visual flight rules (VFR). At the time the aircraft was on course 319° at 1,390 ft at an IAS of 132 kt.

To avoid flying into the layer they interrupted the descent and started climbing to 1,700 ft, which caused them to have an excess altitude over the glide slope of up to 775 ft.

The crew, having lost visual sight of the runway, then maneuvered to intercept the runway 25R localizer.

When the pilots lost the visual references that allowed making the visual approach, they should have started the go around at that point instead of forcing a transition to instrument rules below the minimum safe altitude for the sector.

The weather radar display on the MFD gave them a range of up to 320 miles and 60° on either side of the aircraft’s heading.

When they interrupted their descent maneuver, this 60° coverage could have limited the weather information available to them regarding the runway extension, which coincides with the published missed approach flight path.

Throughout the climb maneuver, in an effort to avoid entering the cloud layer, the crew continued turning to final and were on heading 299° when they resumed the descent.

At that point the radar coverage should have allowed them to gauge the adverse weather situation that hampered the execution of the missed approach procedure.

At the 2.8 NM point the crew regained visual contact with the runway, aware that the approach did not comply with the stability criteria. In their statements, the crew argued that seeing on the radar display the presence of a cumulonimbus cloud that prevented them from executing the published missed approach procedure prompted them to continue the approach and land. What is more, the urgency of the situation and their proximity to the runway prevented them from negotiating an alternative maneuver with ATC.

They considered the possibility of going around to the left or right but ruled out both options due to the presence of other aircraft and obstacles, respectively.

From this point on until they were practically over the runway threshold (0.2 NM), the aircraft was descending at a moderate rate of around 1,000 ft/min.

At 1,000 ft AGL the aircraft was some 620 ft above the ideal altitude at an IAS of 146 kt. It was configured for landing at a distance of 1 NM from the threshold and left of the localizer on an intercept heading of 276°. The Vref for the approach for its landing weight was 133 kt.

Already at this point the stability criteria specified in the operating manuals were not being met. An objective check of these parameters would have made the crew aware of the difficulty of successfully completing the approach.

According to the crew's statements, when the aircraft was at an altitude of 600 ft, the captain, on seeing the first officer's hesitation in light of the unstable approach, decided to take control of the airplane, informing the first officer "I have control", to which the first officer replied "yours". From then on the pilot became the PF and the first officer the PM.

An analysis of the approach segment carried by the first officer as the PF reveals that at no time did he force the descent rate, which remained throughout at normal values. This is notable since had the descent slope used by the first officer been maintained, the aircraft would have overflown most of the runway, making the landing impossible. This indicates a certain degree of unwillingness on the part of the first officer to complete the landing. It is this realization that may have prompted the captain to take the controls.

On doing so, the captain extended the air brakes, which increased their descent rate considerably, to an average value of almost 3,000 ft/min. He also executed a turn to the left of 42° to line up with the runway. This resulted in the activation of a ground proximity (EGPWS) alert, which issued a "Sink rate" caution and twelve "Pull up" warnings until the aircraft reached the radio altitude (see footnote 1); from that point these alerts are inhibited by design. The crew did not react to any of the alerts. They also ignored the EICAS FLT SPLR DEPLOY, which indicates that the air brakes have been extended at an unsafe altitude (below 800 ft).

At 500 ft they were some 400 ft above the theoretical glide slope with a 42° left roll and an IAS of 135 kt. In this situation the first officer, as the PM, should have made the "VITAL ITEMS" call out to inform the captain of the aircraft's unstable approach. Once the decision was made to land, the first officer, trusting the captain's skill, thought that any warning intended to abort the maneuver would be meaningless, so he decided to forego the usual call out.

They flew over the threshold at an altitude of 365 feet, an altitude excess of 315 feet. This time the first officer verbally notified the captain of their high sink rate.

Once over the runway, 0.125 NM past the threshold, the spoilers retracted, only to extend again one second later and remain in that position until well after the aircraft had landed. From the crew's statements it is unclear which of the two retracted the spoilers. The captain could not justify extending them again.

The first officer added engine thrust in an effort to reduce their sink rate.

0.2 NM past the threshold the captain started the flare, raising the nose of the airplane 6° and reducing the sink rate to 1,575 ft/min. The engine thrust, which had been at idle since the captain took over the controls, increased during the flare. The IAS was 139 kt.

At 15:14:23 the nose wheel and the right main gear leg contacted the runway. High vertical acceleration values were recorded (3.66 g's) even though the left and right engines had reached N1 values of 43% and 55%, respectively. The air brakes were extended. The ground spoilers probably did not deploy since the thrust levers were not in the idle position.

The aircraft bounced and one second later it was in an "air" condition, meaning none of the landing gear legs was supporting any weight.

The right leg then contacted the runway once more, again resulting in elevated vertical acceleration values (2.45 g's). It was then that the ground spoilers deployed. The N1 values for the left and right engines were 60% and 75%, respectively, these being the highest values recorded during this phase.

Two seconds later the other two landing gear legs made contact, the highest vertical acceleration value this time being 1.82 g's. The IAS was 129 kt and the N1 values for the left and right engines had dropped to 43% and 40%, respectively.

Once all three legs were resting on the runway the aircraft's speed began to drop rapidly. Twelve seconds elapsed until the aircraft reached a ground speed (GS) of 50 kt. The fact that the air brakes had been extended for a distance of 600 ft while above the runway is believed to have had an effect on the sharp drop experienced by the airplane and on the short landing run.

They did not use reverse thrust to decelerate, which is not considered standard since the operator requires the use of at least idle reverse on all landings. In a situation involving landing beyond the TDZ, which leaves less runway for the landing run, the use of systems designed to shorten the landing run should not be overlooked. As a result it was deduced that the reverse thrust system was not available. The captain did not recall whether they used it or not.

Since the CVR was not available to confirm the crew's actions, it is likely that the urgency of the situation caused them to either omit or improperly read the "Before Landing" checklist, which instructs the crew to arm the reversers. A second opportunity was missed when the "VITAL ITEMS" call out was omitted and which presents an additional barrier to confirm that the airplane is properly configured for landing.

They exited the runway via taxiway R5 and proceeded to their assigned parking stand (296) via taxiways E, J and QS.

Once the aircraft stopped, the flight attendant informed the flight crew of discomfort in her neck as a result of the aircraft's initial contact with the ground.

2.3. Analysis of the go-around maneuver

The table below offers a comparison of the stability criteria specified by the FSF (Flight Safety Foundation), those included by the operator in its manuals, and those that were present during flight ANE 8313.

Stability Criteria			
	FSF	ANE	ANE 8313
1º	Correct flight path	Correct flight path (aligned with runway)	Never on 3° glide slope
2º	Only minor changes	???	Significant: –40° roll / –10° pitch
3º	Vref + 20 Vref	Vref + 20 Vref	Vref + 20 Vref
4º	Configuration OK	Configuration OK	Spoilers from 300' to impact
5º	1000 fpm sink rate	1000 fpm sink rate	Up to 3500 fpm, EGPWS alerts
6º	Thrust for configuration	???	N1 = 26% / N2 = 62%
7º	Briefing + checklists	Briefing + checklists	No CVR
8º	One dot. Wings level at 300'	One dot. Wings level at 300'	LOC 3 dots/GS 3.3 dots (–6°/14°)
9º	Deviations Special briefing	Deviations Special briefing	No special briefing
10º	Unstable at 500' GA	Unstable at 500' GA	No GA

Figure 13. Table comparing the stability criteria of the FSF, the operator and those present on flight ANE 8313

The application of the accepted destabilization criteria should have resulted in the crew's deciding to execute the missed approach procedure.

In its OM A, the operator provides the following instructions on flying in adverse weather conditions:

"Crews must bear in mind the possibility that going around could take the airplane into a storm located in the missed approach path".

This possibility was not considered beforehand and it did not affect the approach maneuver until the crew noticed the presence of the vertically developing clouds using the onboard weather radar.

When a controller offers a crew the option of accepting a visual approach, the crew must be very sure of their ability to carry out both the visual approach and, if visual contact is lost, the corresponding go around (EU OPS 1.400) before accepting the approach.

The go-around procedure published in AIP Spain on the date of accident for the runway 25R approach was:

"Climb on R-246 BCN (runway heading) to 3000 ft and wait for ATC clearance".

In his statement the captain justified his decision not to execute the go-around maneuver by noting the presence of the vertically developing clouds, the presence of obstacles to the right and of other traffic to the left, all of which made it impossible to carry out the published procedure.

This Commission's analysis determined that the crew, had they adhered to published procedures, could have detected the need to go around on three occasions:

- When they lost visual references while executing a visual approach below the Minimum Sector Altitude (MSA).
- At 1,000 ft AGL the stability criteria specified in the operating manuals were clearly not met. An objective check of these parameters would have called the crew's attention to the difficulty involved in successfully completing the approach.
- At 500 ft AGL where the operator requires the crew to ensure that the aircraft is in condition to execute a safe landing by checking the VITAL ITEMS.

The delay in the decision, conditioned by the desire to land before the storm moved in over the airport, meant that the crew worked the aircraft into a situation from which it was difficult to exit.

The air traffic situation at the hypothetical go-around moment was (see Figure 11):

- Aircraft with call sign ANE 8092. Had taken off from runway 25L and was at an altitude of 2,800 ft, climbing to FL 120 and heading away from the airport.
- Aircraft with call sign VLG 6106. Had taken off from runway 25L before the above aircraft and was at an altitude of 7,200 ft, climbing to FL 190 and heading away from the airport.
- Aircraft with call sign VLG 8034. This aircraft was behind the accident aircraft in the landing sequence. It was making a 360° turn at an altitude of 1,400 ft SE of the airport.

- Aircraft with call sign UTA 5187. This aircraft was behind VLG 8034 in the landing sequence and was at 4,400 ft descending to 3,500 ft to the east of the airport.
- Aircraft with call sign JKK 2851. This aircraft was the last to take off from Barcelona in this time period. It started its takeoff run at 15:15:45, that is, about 1:20 minutes after the landing of ANE 8313.

Given this situation, the decision to go around and avoid the storm would have been the best option since any southerly deviation course would have been feasible, with ATC being responsible for ensuring aircraft separation during the maneuver.

In its OM A, the operator includes as a stabilization criterion the need to have read the associated checklists and have completed the proper briefings. This observation, however, does not appear in the PRM operating reference document, as a result of which a recommendation is issued to include it.

In its PRM, the operator adds the VITAL ITEMS call out as an additional barrier to destabilization. This call out involves checking the airplane is properly configured for the imminent landing. It is recommended that the operator clarify in this same document that the performance of the VITAL ITEMS check does not exclude nor substitute the execution of the normal procedures associated with this phase of flight.

2.4. Organization of the operator

2.4.1. *Flight recorders*

The crew logged the "hard landing" in the relevant documentation and then did a visual inspection of the aircraft that revealed nothing out of the ordinary.

The operator's maintenance personnel also inspected the aircraft as a result of the "hard landing" reported by the crew. This inspection did reveal structural damage.

Since the cockpit voice recorder (CVR) had not been disconnected, when maintenance powered up the aircraft it was turned on and consequently taped over itself, resulting in the total loss of the information on the accident flight.

Air Nostrum is planning to include in its manuals a procedure that avoids this situation by issuing instructions intended to safeguard the data recorded on the aircraft's systems in the event of an accident or incident.

It should be noted that this situation is not exclusive to this operator, and that the accumulated experience from other investigations into similar events has revealed how practically no Spanish operator addresses this procedurally in its manuals.

Publication of Regulation (UE) 965/2012 (see 1.18.2) has amended this deficiency by introducing new requirements on this matter; specifically concerning the OM that must include procedures to ensure the preservation of the flight recorders.

Although from a normative point of view the deficiency has been duly corrected with the publication of said Regulation, from a practical point of view its implementation is still pending. That is why it seems prudent to adopt measures intended to check the inclusion of this requirement in the OM. As a result, a safety recommendation is issued to AESA, as the supervisory agency, to ensure the fulfillment of such requirement by Spanish operators.

2.4.2. *FDM*

In keeping with regulations, the operator has a flight data monitoring program whose goal is to ensure that its aircraft are operated in compliance with safety standards. This program leads to statistical findings that result in the adoption of corrective actions aimed at minimizing or avoiding any deviations.

Specifically, flight ANE 8313 merited an FDM analysis whose conclusions led the operator to reiterate to its crews the need to conduct stabilized approaches. In this regard, the findings have been disseminated both at CRM and at flight safety conferences. The airline's Training Department has also underscored the importance of this policy by monitoring its use during recurring simulator sessions.

The quarterly flight safety magazine also carried articles on stabilized approaches that emphasized the important role of the F/O as a barrier to keep the operation from drifting into an undesired state and, if need be, to carry out the corrective action.

2.4.3. *Manuals*

2.4.3.1. Visual approach

As indicated in point 1.10.1.1, Section 1.2.4 of the PRM has guidelines and criteria regarding when to execute a go around.

While it provides the following instruction for visual approaches: "Do not descend unless visual contact with the ground and/or lights is established and maintained", it does not include any instructions on whether to continue with a visual approach or not when visual conditions or contact with the ground are lost during such an approach.

If the references needed to conduct a visual approach are lost due to changing weather conditions when the aircraft is below the MSA, it would not be possible to continue the maneuver by transitioning to IFR, meaning that a go around would be required.

Therefore it seems advisable that the PRM include clear and concise instructions on the requirement to go around when visual conditions or visual contact with the ground are lost on a visual approach when the aircraft is below the MSA. A safety recommendation is issued in this regard.

2.4.3.2. EGPWS alerts

EU OPS 1.395 specifies that when undue proximity to the ground is detected by any flight crew member or by a ground proximity warning system, the commander or the pilot to who conduct of the flight has been delegated shall ensure that *corrective action is initiated immediately* to establish safe flight conditions.

EGPWS alerts warn of a potentially dangerous situation that requires immediate action by the crew, as specified in the procedures.

The operator's manuals include detailed information on the different alerts of the enhanced ground proximity warning system (EGPWS) and the "recommended actions" to take in the event of an alert (OM A and PRM).

The investigation into this accident has determined that the crew, despite receiving repeated EGPWS alerts, ignored them and did not carry out any procedure in response to them.

In this regard, the operator should instruct its crews to act in accordance with the aforementioned regulation by having its documentation clearly specify those procedures and actions to be unfailingly followed in the event of a ground detection system activation.

To this end, a safety recommendation is issued to the operator so that it modify the term "recommended" in its manual (eliminating this way the optional sense) and require its crews to respond when faced with ground proximity alerts.

2.4.3.3. Checklists

The first recorded accidents involving checklists occurred in 1968 (Chicago and Anchorage).

In the wake of these and other accidents, studies were conducted, such as the NTSB/SS-94/01[5], which underscored the need to pay greater attention to the influence of human factors on the design and use of checklists.

[6] National Transportation Safety Board, Safety Study; a Review of Flightcrew-involved Major Accidents of US Carriers,1978 through 1980.

The research by Degani & Wiener, Turner, the CAA (CAP 676) and even the FAA in its "HUMAN PERFORMANCE CONSIDERATIONS IN THE USE AND DESIGN OF AIRCRAFT CHECKLISTS" drew conclusions regarding the criteria to which checklists should adhere.

Based on the information provided by the crew of the aircraft involved in the accident that is the subject of this report, the "Before Landing" checklist was either not read or read improperly.

Also, and although the investigation into this event has concluded that this list did not contribute to the accident, an analysis of it revealed that it is not written in keeping with the aforementioned criteria. Specifically, the items to be completed are not listed in order of importance. Moreover, items are to be checked and read back by the PF, whereas the criterion recommended for critical items (flaps, gear, reversers, etc.) is that they be confirmed by both pilots.

As a result, and bearing in mind that checklists are essential to the safety of operations, it is necessary that a safety recommendation be issued to the aircraft operator so that its "Before Landing" checklist be modified so that it adheres to commonly recommended criteria.

In its Pilot Reference Manual (PRM), the operator specifies as mandatory for all its crews that the PM must make a call out of VITAL ITEMS at a radio altitude of 500 feet that reaffirms that the aircraft is in condition to make a safe landing.

This procedure is not envisaged in Bombardier's documentation and includes checks that are already made as part of the "Before Landing" checklist. Having this redundancy involving two procedures to be completed in a brief span of time could prompt crews to simplify the operation by completing only one of them.

As a result a recommendation is issued to the operator that it clarify that the VITAL ITEMS is a call out that confirms a situation but does not substitute the performance of normal checklists.

Also noted is the fact that the reference stabilization criteria specified by the FSF (Flight Safety Foundation) include the condition that all of the relevant checklists and briefings must be completed in order for an approach to be regarded as stabilized.

This condition is envisaged by the operator in its OM A but not in its Pilot Reference Manual (OM B). As a result, and so as to underscore the importance of this aspect, a recommendation is issued to the operator that it include in the PRM the need to have the checklists and briefings completed as one of the criteria required in order to consider an approach as stabilized.

2.4.3.4. Obstacle on go-around course

Based on the crew's accounts, when they regained visual contact with the runway they realized that it was not possible to make the approach under the required stabilization conditions. Practically simultaneously they also noticed that the go-around flight path was affected by cumulonimbus clouds, making it unviable.

As concluded in Section 2.3, the best option would have been to go around without entering the cumulonimbus clouds and immediately report their situation to ATC so they could take the measures necessary to maintain separation with the other aircraft.

The crew, however, both during the event and days afterward, thought that in these conditions their only option was to land, considering unviable the option of executing a missed approach that differed from the published procedure.

The only mention found in the operator's manuals regarding what to do if the go around procedure is not available was in the chapter on flying in adverse weather conditions, which contains a warning to avoid making a go around that takes the airplane into a storm located on the go around flight path. No instructions are provided, however, about what to do in these cases.

In light of the above it would be prudent to make available procedures on the actions to take if the standard go around maneuver cannot be executed and incorporate said procedures into manuals and the training program. A safety recommendation is issued in this regard.

2.5. Human factors

Since the CVR recording was not available, the investigation had to rely on the accounts of the two pilots.

2.5.1. *Situational awareness*

In his statement, the captain stated that the controller should have given them information on the location of the cumulonimbus clouds that affected the maneuver. This shows that he was unaware of the fact that the information available to controllers is not sufficient to ascertain the actual weather situation and how it is evolving. In any event, the crew's assumption of thinking there were no significant weather events on the runway extension because the controller had not mentioned anything in this regard created in them a mental picture of their surroundings that did not conform to the actual conditions, resulting in a loss of situational awareness.

From that moment on, the decision-making process was significantly conditioned by this fact. In this regard, the crew, even if they are aware at a given moment that they should abort the landing, could decide to force it a little more and continue the maneuver, trusting that the option to go around will still be available to them.

2.5.2. *Communications*

In order to transition from an instrument to a visual approach, the crew must first determine its viability. As specified in the operator's manuals, a visual approach is to be initiated only if the weather conditions are such that the segment in question can be flown entirely in VMC. Therefore, before accepting or rejecting an offer to make a visual approach, the crew should have assessed its viability and, if favorable, briefed their new situation.

In this case, when the controller offered the crew the option of making a visual approach, they quickly replied in the affirmative. The speed with which they replied suggests that they did not assess the viability of making a visual approach since there was not enough time to do so. This would have to be regarded as poor communications.

Another conclusion can be drawn from the situation described: that the crew may not have made said assessment because they were convinced that it was possible to make a visual approach without any interference. This conviction could have been based solely on the information that the clouds had not yet affected the approach segment between the 4 NM point and the runway.

Although the loss of visual conditions involved a significant change in the circumstances of the maneuver, the crew's statements indicate that the continuity of the maneuver was not discussed, which provides another example of poor communications.

The lack of attention paid to the automatic ground proximity alerts issued by the EGPWS could also be regarded as a breakdown in communications.

2.5.3. *Teamwork*

Based on the captain's statement, in light of the first officer's hesitation, he took the controls and carried out his decision. The fact is that the captain took the controls at an altitude of about 600 feet, 0.5 miles away from the threshold.

When he took control, the captain reduced the throttle to idle. Two seconds before impact, he asked the first officer to advance the throttles, which he did.

He stated, however, that he did not notice the first officer increase thrust since the delay in the engines spooling up had no effect on reducing the sink rate or on controlling the landing maneuver.

The hasty and risky decision to continue was made by the captain. One's performance under these conditions is affected by one's training and experience.

Faced with doubts about its viability, the first officer was unable to complete the maneuver. Despite acknowledging the destabilization, he accepted the captain's decision without knowing how to convey the risk he sensed.

Both the captain, who had a total of 7,300 flight hours (6,500 on the type), and the first officer, with 3,000 total hours (1,000 on the type), were experienced pilots.

While the specific characteristics of the two pilots (experience, age difference) do not reveal any relevant factors that could have affected the power gradient in the cockpit, the captain's decision was not questioned by the first officer, whose uncertainty had been generated by his appreciation of the complexity of the situation.

The fact that it was their first time flying together should have resulted in maximum adherence to standard operating procedures (SOP) so as to facilitate the detection of any deviations and promote teamwork.

However, as the captain stated:

He ended up choosing the destabilization and entering the runway. The captain continues to wonder what he could have done differently and still sees no other possible alternatives.

2.5.4. *Omissions*

In his statement the first officer said:

> "... The subsequent braking action was normal and we exited the runway via R5, which is the one that is normally used, so despite the bounce, the landing wasn't too long..."

The landing run was so short due to the fact that the air brakes had been deployed for over 500 feet while over the runway. Even though the crew retracted the air brakes at one point before the landing, they were redeployed by the captain, who was overwhelmed by the circumstances and could not justify this action. This is indicative of the complexity of the situation that enveloped the crew.

They did not use reverse thrust because the stress of the unusual situation could have caused them to forget to arm this system or to do so incorrectly. Arming the system is included in the "Before Landing" checklist.

The lack of time given the haste of the situation should have caused the captain to "apply the rule", that is, to go around.

This behavior arises from a previously trained situation. Having external unforeseen factors leads to improvisation and to deviation from standard procedures, which does not always lead to the correct decision.

The aircraft some 4 miles behind them in the sequence (VLG 8034) and that at the time was at the same altitude (1,600 ft) as ANE 8313 requested to do a 360° because they were too high. Two minutes later VLG 8034 informed the controller that in the event of a go around, they would turn left on heading 180°. The decision made by this crew was made easier by the time they had available, which enabled them to better analyze the situation (decision process).

2.5.5. *Threat and error management (TEM)*

What the instability achieved was an "undesired state" since the captain himself stated that the cumulonimbus ahead of them made it impossible to go around, so he opted for the destabilization and to enter the runway.

In his statement the captain argued that the information available during each approach phase was as expected and their decisions reasonable until they were on final, where their only option was to forego the norm while considering the potential risks, with the chance of colliding with aircraft on the downwind leg to the left or entering an area of red/magenta returns straight ahead. He finally opted to destabilize the approach and land. The captain still asks himself what else he could have done differently, but continues to see no other alternatives.

For his part, the first officer stated that he did not make the standard stabilization call out (vital items) since he thought that once the decision to land was made under those conditions, the call outs were not necessary.

This improper management resulted in a risk situation that translated into significant damage to the aircraft.

3. CONCLUSIONS

3.1. Findings

- The acceptance of the visual approach maneuver was based on the weather information received, which did not reflect the presence of storm cells along the extended runway centerline. Communications with the controller were lacking in that the crew could have requested more information to facilitate the approach.
- When they lost visual flight conditions, they improvised a solution that led to the destabilization of the maneuver. A go around at that point would have avoided the problems they faced afterwards. There was a lack of situational awareness.
- The decision to land forced them to shorten the maneuver excessively under non-visual conditions, resulting in a destabilized approach. Forcing the maneuver is regarded as faulty error management.
- The realization that there was adverse weather on short final greatly conditioned the captain's decision not to go around. Once again there was improper threat management caused by the stress involved in the situation.
- Although the weather information gathered did not conclusively point to the presence of cumulonimbus clouds, the actions of the aircraft following them infer that the published missed approach procedure was affected by adverse conditions.
- The hesitation of the PF (first officer) when faced by the destabilization denotes a lack of communication.
- The captain took control of the aircraft at 600 ft and executed a maneuver that involved a high rate of descent. Doing this without giving the first officer another option is indicative of a certain authoritarian attitude that tilted the power gradient in the cockpit.
- Faced with the captain's sudden reaction, the first officer was relegated to the background and saw no point in making the vital items call out. The lack of communication between them could have conditioned the captain's actions.
- There was also a lack of communication regarding the lack of attention paid to the alerts of the first officer and the EGPWS.
- The technique of using the air brakes intuitively during the landing was incorrect and led to difficulty in reducing the steep descent gradient. Their use is also prohibited below 300 ft.
- The stress generated by the non-standard approach could have led to the omission or faulty completion of the "Before Landing" checklist, resulting in the airplane being improperly configured for landing (reversers not armed and spoilers deployed).
- In its OM A, the operator includes as a stabilization criterion the need to have read the associated checklists and to have completed the proper briefings. This observation, however, does not appear in the PRM operating reference document.
- In its PRM, the operator adds the VITAL ITEMS call out as an additional barrier to destabilization. This call out involves checking the airplane is properly configured for the imminent landing but it must not exclude or replace the execution of the normal procedures associated with this phase of flight.

- The "Before Landing" checklist is not written in accordance with most commonly recommended criteria: the items to be completed are not listed in order of importance. Moreover, items are to be checked and read back by the PF, whereas the criterion recommended for critical items (flaps, gear, reversers, etc.) is that they be confirmed by both pilots.
- In its operating documents (OM A and B) the operator lists those situations in which its crews are required to go around. Not included in these documents is the need to go around if the required visual references are lost during a visual maneuver.
- The improper threat and error management that led to an undesired state could have been solved by using the training received and going around to the left. This was the safest option and the one carried out by the traffic behind the accident aircraft.

3.2. Causes

This accident was caused by:

The execution of a destabilized approach brought about by the captain's decision to try to descend at rates in excess of 2,500 ft/min and with the air brakes deployed from 600 ft AGL to the ground.

The following contributing factors have also been identified:

The presence of an adverse weather situation that was different from expected and the lack of communication between the two pilots, which caused the crew to lose situational awareness and to ignore the EGPWS warnings.

4. SAFETY RECOMMENDATIONS

The investigation into this accident underscored the presence of certain shortcomings and/or deficiencies in the operational documentation of the aircraft's operators, the modification, correction or adaptation of which are considered important to improve the safety of operations. To this end, the following recommendation is issued:

REC 15/13. It is recommended that Air Nostrum modify its operational documentation as follows:

- Include in the PRM the need to have checklists and briefings completed as one of the criteria required to have an approach be regarded as stabilized.
- Clarify that the VITAL ITEMS call out confirms a situation but does not replace the execution of normal checklists.
- Replace the term "recommended" from the actions contained in its manuals in regard to the ground proximity alerts issued by the EGPWS, thus removing the option of not carrying out actions that should be executed immediately and unfailingly.
- Modify the "Before Landing" checklist so that it reflects the most commonly accepted checklist writing criteria.
- Include the need to perform a go around whenever the required visual references are lost during a visual approach.

The investigation into this event also revealed the presence of certain shortcomings in the area of crew coordination and CRM, as well as in the actions to take when facing situations in which the published procedures are not applicable. As a result, the following recommendation is issued to the aircraft operator so that it enhance the training of its crews in the areas noted:

REC 16/13. It is recommended that Air Nostrum enhance its crew training:

- Through scenarios as demanding as the one involved in this accident, and stressing crew coordination and CRM skills.
- By writing guidelines that facilitate the modification of operations in those cases where the anticipated procedure is constrained, and that it include them in its operational documentation and provide the relevant training to its crews.

Although EU OPS 1.160 sets out the obligations of air operators as regards the preservation, production and use of flight recorder recordings in the event of an accident or incident, this investigation has revealed that, as reflected in Section 2.4.1, practically no Spanish operator has procedures in its manuals intended to preserve flight recorders after an accident or incident, resulting in the loss of vital information during several investigations. As a result, a safety recommendation is issued to AESA in an effort to guarantee the preservation of flight recorder data.

REC 17/13. It is recommended that AESA ensure that Spanish operators comply with the requirements established in the Regulation (EU) n° 965/2012, in order them to include in their OMs procedures to ensure the preservation of the flight recorders following a reportable event.

APPENDIX

APPENDIX A
ILS approach to runway 25R at Barcelona

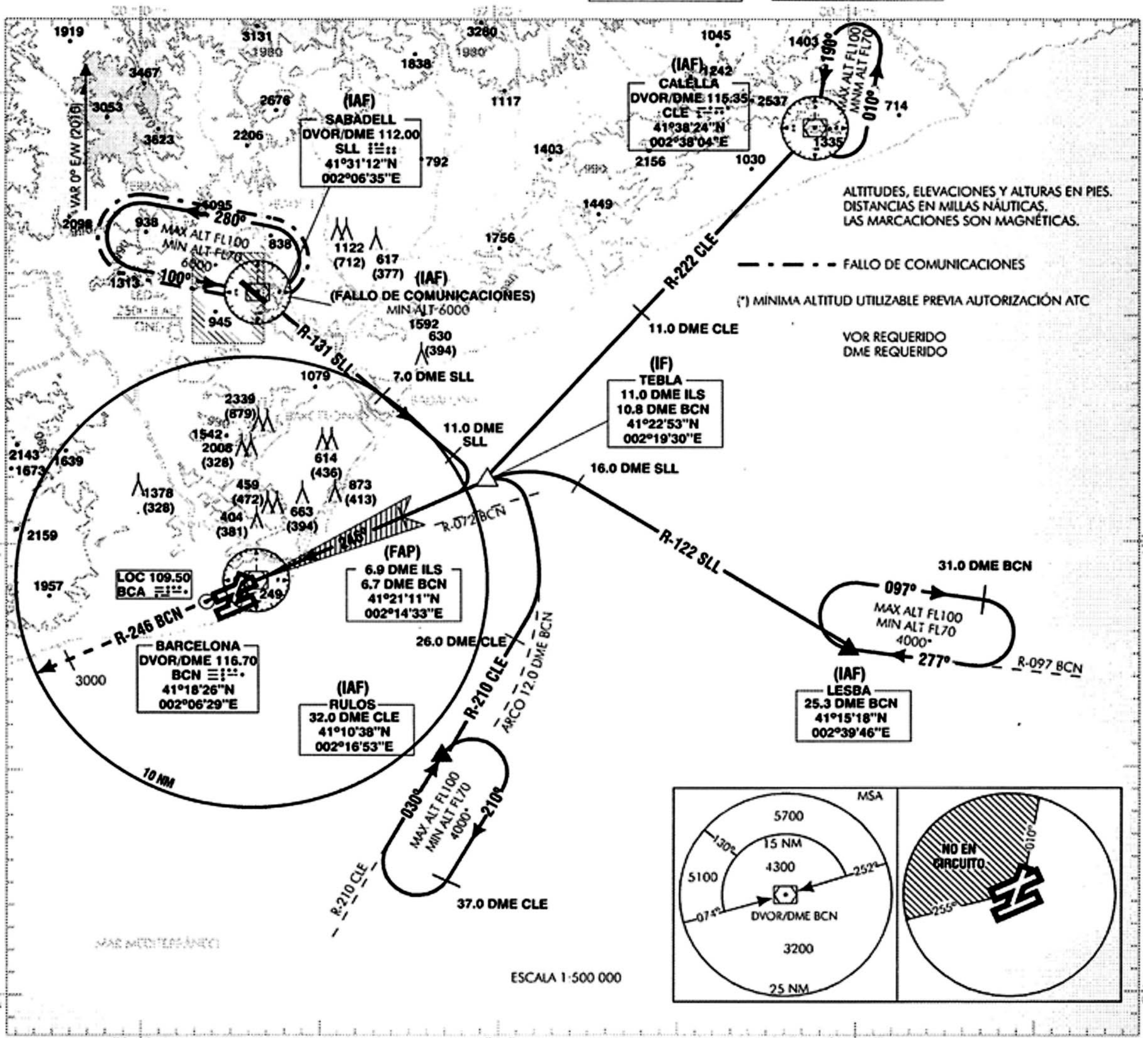
CARTA DE APROXIMACIÓN POR INSTRUMENTOS-OACI

ELEV AD 14

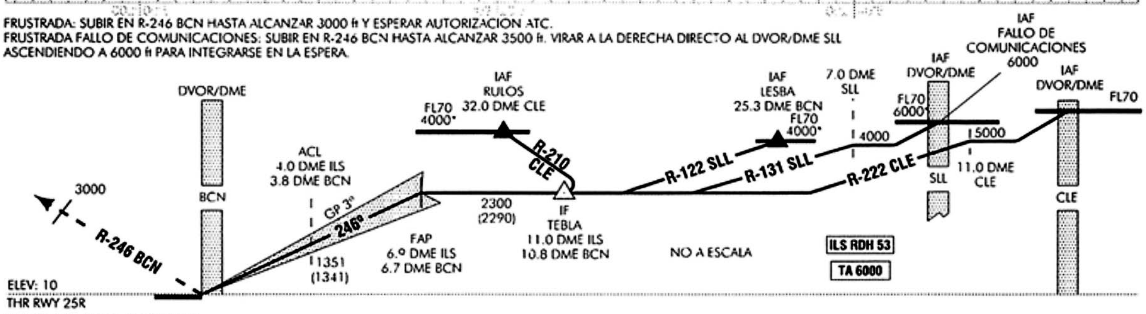
APP	119.100
TWR	118.100
	118.325
ATIS	118.650

GMC E	121.850
GMC W	121.700
GMC S	121.650

BARCELONA ILS RWY 25R



FRUSTRADA: SUBIR EN R-246 BCN HASTA ALCANZAR 3000 ft Y ESPERAR AUTORIZACIÓN ATC.
FRUSTRADA FALLO DE COMUNICACIONES: SUBIR EN R-246 BCN HASTA ALCANZAR 3500 ft. VIRAR A LA DERECHA DIRECTO AL DVOR/DME SLL ASCENDIENDO A 6000 ft PARA INTEGRARSE EN LA ESPERA.



HGT REF ELEV THR RWY 25R

OCA/H		A	B	C	D
STA	CAT I 2.5%	305 (295)	317 (307)	325 (315)	336 (326)
	CAT I 3%	215 (205)	227 (217)	235 (225)	246 (236)
	CAT II 2.5%	(216)	(233)	(245)	(259)
	CAT II 3%	(97)	(114)	(125)	(140)
En circuito (H) sobre 14		580 (570)	700 (690)	890 (880)	1300 (1290)

GS	kt	80	100	120	140	160	180
FAP-THR: 6.9 NM	min:s	5:10	4:08	3:27	2:57	2:35	2:18
FAF-MAPT:	min:s						
ROD: 5.2 %	ft/min	425	531	637	743	849	955

ALT/HGT DME (ILS) FNA

13 DME	12 DME	11 DME	10 DME	9 DME	8 DME	7 DME	6 DME	5 DME	4 DME	3 DME	2 DME	1 DME
							2010 (2000)	1680 (1670)	1360 (1350)	1030 (1020)	710 (700)	

CAMBIOS: PROCEDIMIENTO, COORDENADAS IF/FAP, RENUMERACIÓN, DECLINACIÓN MAGNÉTICA, SIMBOLOGÍA, OBSTÁCULOS.

WEF 29-JUL-10 (AIRAC AMDT 06/10) AIP-ESPAÑA AD 2-LEBL IAC/13