DATA SUMMARY

LOCATION

Date and time	**31 October 2008; 07:15 UTC**
Site	**Lanzarote Airport**

AIRCRAFT

Registration	**EC-HJQ**
Type and model	**BOEING 737-800 S/N: 28387**
Operator	**Air Europa**

Engines

Type and model	**CFM 56-7B**
Number	**2**

CREW

	Captain	Copilot
Age	**50 years old**	**35 years old**
Licence	**ATPL(A)**	**ATPL(A)**
Total flight hours	**14,330 h**	**3,818 h**
Flight hours on the type	**8,388 h**	**806 h**

INJURIES

	Fatal	Serious	Minor/None
Crew			**6**
Passengers			**74**
Third persons			

DAMAGE

Aircraft	**Damage to all landing gear tires**
Third parties	**Two approach lights on the opposite threshold**

FLIGHT DATA

Operation	**Commercial air transport – Passenger – Non-scheduled**
Phase of flight	**Landing**

REPORT

Date of approval	**17 October 2011**

1. FACTUAL INFORMATION

1.1. History of the flight

The day before the incident, the crew had started its duty period in the evening in Lanzarote at 20:40[1] to fly the ACE-GLA-ACE (Lanzarote-Glasgow-Lanzarote) route. They had taken off at 22:01, a few minutes after the scheduled departure time. The flight to Glasgow was uneventful. From there they took off once more at 03:15 for Lanzarote with 74 passengers onboard. The flight callsign was UX-196 and the flight was scheduled to last 4 hours and 19 minutes. On this second leg the copilot (FO) was the pilot flying (PF). The climb and cruise flight phases at Flight Level (FL) 390 transpired without incident.

Four minutes before initiating the descent to Lanzarote, the captain was resting in his seat while the FO listened to the Lanzarote ATIS (Automatic Terminal Information Service), which reported that runway 03 was in use and that weather conditions were good.

Shortly thereafter they were cleared by Casablanca Control to descend to FL250 and to change frequency to Canaries Control, who in turn cleared them to continue descending to FL130 and proceed on STAR (standard arrival) TERTO 1P, as specified in the flight plan and whose information had been input into the flight management computer (FMC). The descent was started in automatic mode from the TOD (top of descent), as calculated by the FMC. Immediately afterwards the FO held a detailed approach briefing for runway 03.

Once at FL210, they were transferred to the Canaries Approach frequency. The FO changed frequency and, at the captain's request, asked about the possibility of using runway 21. About two minutes later they were cleared to proceed to the fix at mile 11 on the runway 21 final at Lanzarote. At that time they were at an altitude of 14,600 ft and 30.5 nautical miles (NM) away from the runway 21 threshold.

The FO then started to reprogram the FMC, but had difficulty finding the point to which they had been routed, which resulted in a delay of almost two minutes. In the meantime, the captain prompted him to descend more, though at no time did he himself manipulate any of the airplane's controls.

They were 21 NM from the runway 21 threshold and had an indicated airspeed (IAS) of 315 kt when they reached the altitude of 10,000 ft.

During the last 1,000 ft, the enhanced ground proximity warning system (EGPWS) was repeatedly issuing "SINK RATE", "PULL UP" and "TOO LOW TERRAIN" warnings.

[1] All times in this report are in UTC unless otherwise specified. UTC was the same as local time (LT) in the Canaries on the date of the incident.

They flew over the runway 21 threshold at a radioaltitude (RA) of approximately 180 ft, with an IAS of 175 kt (Vref+41) and the flaps deployed to an intermediate position of 25°, as a result of the "flap load relief" mechanism.

As the captain stated later, he realized that the landing was going to be long and that the runway was wet. That is why he decided to increase the selected thrust on the autobrake system from the number 2 position that was initially set to the maximum (MAX) position.

After a prolonged flare, the airplane touched the runway at about its halfway point, some 1,300 m from the 21 threshold and at a speed of 157 kt (Vref+23).

The autobrake was disengaged five seconds after touchdown. Maximum manual braking was applied from that point on.

The reversers were not engaged until 13 seconds after touchdown, and the engines were unable to reach sufficient rpm's until the airplane had practically come to a full stop.

The airplane ran off the end of the runway at a ground speed (GS) of 51 kt and traveled over the 60 m of the stopway, before stopping approximately one meter away from the 03 threshold jet blast barrier, alongside the airport's perimeter fence.

The control tower immediately alerted emergency services, which quickly arrived at the airplane's location, though their intervention was not necessary.

The passengers disembarked via the aft left door (L2) using an external ladder, after which they were then taken to the airport terminal. None of them required medical assistance.

Figure 1. Final aircraft position

Figure 2. Damage to the nosewheel landing gear

The material damage was limited to the airplane's tires, which had to be replaced following an inspection by the airline's own maintenance personnel, and to two landing approach lights on the opposite threshold.

1.2. Personnel information

The crew had valid licenses, was properly qualified for the flight assigned and their rest time prior to their duty period had exceeded the minimum required.

1.2.1. *Flight preparations*

The members of the crew met as scheduled at the Lanzarote Airport at 20:40 on 30 October, to fly the scheduled route ACE-GLA-ACE. The FO reported arriving a little earlier, as was his custom, to review the flight dispatch information in detail.

During the flight preparation it was decided that the captain would be the PF for the ACE-GLA leg, with the FO flying the return leg.

1.2.2. *Duty and rest periods*

The captain had rested for 22 h prior to the flight, while the FO had rested for 31 h.

Regulation 859/2008 (EU-OPS) was published on 20 August 2008. Subpart Q of said statute regulates crew duty and rest periods differently from the regulation that had been in effect until then, namely Operating Circular 16 B of Spain's Directorate General for Civil Aviation (DGAC). When the crew met at the airport, the captain had doubts concerning the legality of their scheduled activity in light of the new regulation, as a result of which he inquired with the airline, which confirmed that the activity was scheduled to last 10 hours and 30 minutes, below the maximum authorized of 11 hours and considering that the entirety of the activity would take place within the circadian rhythm phase of lowest performance.

During the return flight to Lanzarote, the captain had been resting in his seat for about 40 minutes prior to initiating the descent while the FO listened to the Lanzarote ATIS through the cockpit speakers.

1.2.3. *CRM (Crew Resource Management) training received by the pilots*

Both pilots had received CRM training provided by the company's own instructors following a DGAC-approved model. This training was provided annually.

During the CRM courses provided by the airline over the three previous years, the training received by the captain had emphasized the following topics: analysis of accident statistics, threats, errors, barriers, situational awareness, the error chain, notechs (no technical skills), stress management, communicating with the passenger cabin, automation, leadership, assertiveness, teamwork and decision making.

The FO had received his initial training at the airline in 2007, covering basic concepts involving CRM, safety culture and the company's approach to these areas. He received specific training on decision making, leadership, team concept, assertiveness, notechs, automation and communications. The following year he received the same training as the captain.

These courses are organized in workshops with instructor-led debates and practical exercises.

1.3. Aircraft information

1.3.1. *General*

The Boeing 737-85P aircraft, registration EC-HJQ, was manufactured in the year 2000 and had 30,677 flight hours and 14,740 cycles. It had Airworthiness Certificate no.

4617, valid until April 2009. A check of its recent record of malfunctions did not show any repeated or significant malfunctions, while the Hold Item List (HIL) had only item involving an intermittent fault in one of the display units (DU).

The investigation did not reveal any signs of a malfunction in any of the aircraft's systems during the incident flight.

According to the flight's load sheet, the aircraft had a planned landing weight of 53,510 kg, the maximum authorized being 66,360 kg. The landing weight recorded on the flight data recorder was 54,000 kg.

The landing reference speed (Vref) at this weight for a 30° flap deflection was 134 kt.

1.3.2. *Idle modes for the Boeing 737/800 engine*

Low rpm operations on the B733-800 engine have three idle modes, adapted to different flying conditions.

Whenever the throttle lever is placed in the idle position, the electronic engine control (EEC) automatically selects the ground idle, flight idle or approach idle, depending on the phase of flight.

Ground idle is selected for ground operations and flight idle for most flight phases. Approach idle is selected if the flaps are in a landing configuration or if anti-ice is turned on for both engines.

For the same indicated airspeed and altitude, N1 and N2 % RPM will be higher for approach idle than for flight idle. This higher RPM setting improves engine acceleration in the event that the pilot is forced to carry out a go around maneuver.

Approach idle is in effect until after touchdown, after which ground idle is selected.

In flight, if a fault keeps the EEC from receiving flap or anti-ice indications, approach idle is selected when below 15,000 feet MSL.

1.3.3. *Flap load relief*

In order to protect the flaps from excessive aerodynamic loads at high airspeeds, the flaps/slats electronic unit (FSEU) provides a flap load relief function, which is only in operation for flap positions of 30° and 40°.

When 40° flaps are selected, the system retracts them to 30° if the indicated airspeed is above 163 kt, re-extending them when the indicated airspeed drops below 158 kt.

When 30° flaps are selected, the system retracts them to 25° if the indicated airspeed exceeds 176 kt and re-extends them when the indicated airspeed drops below 171 kt. The flaps lever is not moved in either case, though the flaps indicator does show the actual position of the flaps (retracted and re-extended).

1.3.4. *Landing distances*

The tables published by Boeing in its QRH, titled "Normal Configuration Landing Distances", show that with the flaps down 30°, a dry runway, maximum manual braking and for the airplane's actual weight and speed values at landing, the landing distance (measured from 50 ft above the threshold) is 1,025 m. The corresponding landing run (measured from the contact point with the runway) is 720 m.

If instead of maximum continuous manual braking we consider the maximum automatic braking conditions under which this landing started, the resulting landing run is 965 m.

According to Boeing 737 FCTM "Flight Crew Training Manual", the maximum braking landing distances included in the QRH must not exceed the 60% of the real available distance, in order to provide adequate safety margins. Considering this, the minimum required runway length would be 1,712 m. Lanzarote runway is 2,400 m long, thus it exceeds in more than 700 m the minimum runway length required for this type of aircraft.

1.4. Meteorological information

Visual meteorological conditions (VMC) prevailed during the approach to Lanzarote Airport.

The last aviation routine weather report (METAR) issued prior to the aircraft's landing, at 07:00, indicated variable winds at 2 kt, visibility in excess of 10 km, few clouds at 2,500 ft, scattered at 10,000 ft, a temperature of 18° C, dew point of 14° C and a local atmospheric pressure at sea level (QNH) of 1,014 hPa.

The 06:30 METAR did not report any significant weather events.

The 06:00 METAR indicated rain on present weather.

At the time the landing was authorized, the wind was shifting to 280° and its speed was 8 kt.

A check of the precipitation table provided by the airport's weather office revealed that 7 mm (7 l/m^2) of rain had fallen between 05:40 and 06:00, while a negligible amount (less than 1 mm) had fallen between 06:00 and 06:10. No more rain fell at the airport until after 13:00.

The statements from both members of the flight crew and from other airport personnel indicated that water had caused the runway surface to change color. A cloud of pulverized water also appeared as a result of the airplane's wheel contacting the runway surface. It was thus still damp or wet when the airplane landed.

1.5. Communications

A transcript of the tape made by the Lanzarote Tower was available to investigators. Additionally, the airplane's cockpit voice recorder (CVR) contained all of the conversations held between the crew and air traffic control (ATC) in Casablanca, Canaries and Lanzarote and with the airline operations office.

The quality of the communications was good at all times.

A summarized timeline of the communications, along with certain significant data of the flight path as obtained from the flight recorders, is given in 1.7.

1.6. Aerodrome information

The Lanzarote Airport is an ICAO (International Civil Aviation Organization) category 4E international civil airport. It is located 5 km southwest of Arrecife at an elevation of 47 ft and its single runway, 03-21, has a length of 2,400 m and a width of 45 m.

At the date of the accident, the airport had two stopways (SWY) at either end of the runway measuring 60 × 45 m, but it didn't have Runway End Safety Area (RESA). The objective of this RESA is to provide a protection zone beyond the strip and the stopping zones, thus reducing the damage risk to a plane landing too long or too short.

Later on, on October 2010, as it is reflected in its pertinent AIP amendment, the stopping zones were eliminated in order to adapt the strip dimensions to the ICAO requirements. This led to reduce the Accelerate-Stop Distance Available (ASDA).

A new AIP amendment, introduced in April 2011, stated the adding of a RESA at the runway 21 end.

Presently, the 03 end does not feature a protection zone yet, but this deficiency has been detected by AENA, which has foreseen to displace the 03 end, modifying its beacons and pavement in order to have a RESA also at the end of this runway. The investment for the works is already approved and the estimated date for its termination is October 2012.

With the existing configuration on the accident day, the stated landing distance available (LDA) in both directions was 2,400 m.

Runway 21 has a negative 0.5% gradient for the first 1,850 m and a 0.01% gradient for the remaining 550 m.

The AIP states that runway 03 will be preferentially used anytime the tailwind component does not exceed 10 kt and the braking efficiency is good.

Runway 03 has a standard 3° VOR DME ILS approach.

Runway 21 only has a VOR approach (identifier LTE, located within the airport), whose information is attached as Appendix A. The approach path deviates by 13° with respect to the runway and is at a 3.71° (6.48%) slope due to the presence of obstacles. This slope is significantly greater than the standard 3° (5.24%) and often requires rates of descent (ROD) close to or in excess of 1,000 ft/min.

Runway 21, which was used to land, has a simple 420-m long approach lighting system, threshold identification lights, a 3.7° precision approach path indicator (PAPI) and lighting for the runway centerline, edge and ends.

The Lanzarote ATIS information received by the crew shortly before initiating the descent at 06:50 indicated runway 03 as being in use, a transition level of 70, a 3-kt wind in the touchdown zone varying from 200 to 270°, visibility in excess of 10 km, few clouds at 1,800 ft and broken at 9,000 ft, a temperature of 18 °C and dew point of 14 °C, a QNH of 1,014 hPa and an atmospheric pressure at field elevation (QFE) of 1013 hPa.

1.7. Flight data recorders

Both the cockpit voice (CVR) and the digital flight data (DFDR) recorders were recovered in good condition and found to have recorded the last several hours of the airplane's flight.

The CVR recording lasted two hours and had stopped five minutes after the stoppage of the no. 2 engine, as it was configured to and despite the aircraft being energized by the auxiliary power unit (APU).

The DFDR had recorded discrete and continuous values for over 600 flight parameters. The duration of the recording was in excess of 25 hours. Only the data for this flight's descent and landing phases were analyzed in detail.

1.7.1. *Synchronized timeline of the information on the recordings*

The timeline that follows is intended to provide greater insight into the incident and shows the recordings of the radio communications along with the most relevant information from the CVR and important FDR data. Also included is the airplane's distance from the runway 21 threshold, calculated using the radar traces provided by the Canaries Approach Control Center.

06:50:08

The airplane was cruising at FL 390.

The Lanzarote ATIS is heard on the cockpit speaker: "06:50 RWY in use 03, Transition level 70, wind touch down zone variable 3 kt, variable between 200 and 270 degrees, visibility 10 km or more, clouds few at 1,800 ft broken 9,000 ft temperature 18° dew point 14, QNH 1,014, QFE 1,013, report Lanzarote ATIS information A".

06:54:16

Still cruising at FL 390.

The FO, speaking to the captain, says "still alive" and after a brief exchange with ATC, asks: "Can you take over while I use the restroom for a bit?".

06:54:21

Cruising at FL 390.

Casablanca Control clears flight Air Europa 196 (UX196) to descend to FL 250, but the FO requests permission to stay at FL 390 for a further 20 NM, which the controller grants, leaving the start of the descent to his discretion. The FO replies that he would call when leaving FL 390.

06:57:55

Leaving FL 390.

Coinciding with the start of the descent, Casablanca Control instructs UX196 to contact Canaries on 129.1 MHz.

06:58:24

Descending through FL 379.

Canaries Control clears UX196 to descend to FL 130 and proceed with standard arrival TERTO 1P.

06:58:38

Descending through FL 373.

The FO starts a detailed briefing in which he reviews the TERTO 1P standard terminal arrival route (STAR) for the runway 03 ILS approach. He also reviews the airport chart, mentioning the lights available, landing distances, etc., in addition to going over the fuel remaining and his intention to conduct the maneuver "calmly" in LNAV (lateral navigation) mode.

The captain adds during this briefing that there is a 3° PAPI.

The FO continues by noting the absence of any aeronautical information notices (NOTAMs) affecting them and by stating that the descent is programmed into the FMC at 280 kt/0.78 Mach. He continues by mentioning certain anomalies he had noted on one of his display units while the captain was resting.

07:04:28

Descending through FL 223, IAS 273 kt.

Between now and 07:06:00, the captain is talking via VHF 2 with the handling agent in Lanzarote, informing him of their 07:22 estimated arrival time, requesting three wheelchairs and inquiring about a ticket he needs on arrival to continue on a deadhead trip to Las Palmas.

07:04:56

Descending through FL 213, IAS 275 kt.

Canaries Control requests UX196 to contact Approach on 129.3 MHz.

07:05:06

Descending through FL 209, IAS 273 kt, 47 NM from runway 21.

The captain tells the FO: "just out of curiosity, ask him how the wind for runway 21 is" (garbled) "I don't think they'll let us, but anyway...".

The FO asks Approach "How's it looking for landing in runway 21 in Lanzarote?".

07:05:26

Descending through FL 202, IAS 273 kt, 45 NM from runway 21

Canaries Approach replies: "Europa 196, radar contact, descend to FL 80, speed at your discretion for now... initially I have traffic for 03, but I'll let you know in a moment".

The FO is heard talking to the captain: "he says there's traffic for 03 but he'll let us know, I'm putting 220 and 5,000 on LTE, it's going to pitch down a bit now...".

07:07:29

Descending through FL 155, IAS 283 kt, 32 NM from runway 21.

The FO notes: “The thing is if we head for 21, I have nothing planned, so if they end up giving it to me... I’m going to laugh”.

07:07:51

Descending through FL 146, IAS 284 kt, 30 NM from runway 21.

Canaries Approach calls UX196: “Europa 196 you may proceed to the mile 11 fix, runway 21 to land on 21, continue descent to 5,000 ft, QNH 1,014”.

07:08:12

Descending through FL 138, IAS 280 kt, 28 NM from runway 21.

The FO is heard saying out loud in intermittent sentences what he is inputting into the FMC.

The captain tells the FO, “start descending a lot more, start descending now, set vertical speed 3,500, cause if not...”.

07:08:42

Descending through FL 126, IAS 286 kt, 26 NM from runway 21.

The FO asks the captain in a troubled voice, “we’re going here, to mile 11, right?”. The captain replies, “mile 11, yes”. The FO again asks “There?”, and the captain replies, “I don’t know, but descend”.

07:08:54

FL121, IAS 289 kt, 25 NM from RWY 21.

The FO states, “No, no, something’s not right here... we’re already heading for mile 11, ah... no...”. The captain replies, “Set 4,000 for now”, adding shortly afterward, “Here, to this point”.

07:09:13

FL110, IAS 303 kt, 23 NM from RWY 21.

Canaries Approach calls UX196 to clear its descent to 3,000 ft.

07:09:26

Descending through FL102, IAS 313 kt, 22 NM from runway 21.

The FO once more asks, "What point are we going to? I'm not seeing this point at mile 10, mile 11, it has to be F". The captain replies, "CD21", and the FO, in a relieved voice, says "CD21, ok, that makes sense! Of course, I thought something was off!".

07:09:52

Descending through FL 092, IAS 311 kt, 19 NM from runway 21.

The captain instructs the FO "a bit of speedbrake, cause if not...".

07:10:05

Descending through FL 087, IAS 307 kt, 18 NM from runway 21.

The FO requests the "descent & approach checklist".

07:10:09

Alt. 8,500 ft, IAS 305 kt, 17 NM from RWY 21.

Canaries Approach clears UX196 to make direct VOR approach to Lanzarote runway 21.

07:10:33

Alt. 7,800 ft, IAS 286 kt, 15 NM from RWY 21.

The captain asks the FO, "How's it look? OK?", to which the FO replies "Let's get to it! I'm going to slow down first, if not, forget it... ok?".

The captain adds: "Are you doing it in VNAV (vertical navigation mode)?" The FO replies, "I'll probably do it conventionally, but, yeah, LNAV, if we're cleared, right? Cleared then, I'm putting in the minimums which are 1,700, right? And... VNAV... and we're off. What's this say? 'Unable next altitude' OK."

07:11:22

Alt. 6,800 ft, IAS 258 kt, 11 NM from RWY 21.

The captain is heard reading the descent list: "Pressurization? Are the 50 ft recalls set? Check, everything ok, autobrake on 2, landing data, let's put 1,014 if you want...". At this point the captain interrupts the list to answer the purser, who was informing him via the intercom that the cabin is secure.

07:11:46

Alt. 6,000 ft, IAS 252 kt, 9 NM from RWY 21.

The captain tells the FO to “lower the gear, cause if not...”. The FO replies, “Right, gear down”.

07:11:51

Alt. 5,800 ft, IAS 250 kt, 9 NM from RWY 21.

The FO makes a series of colloquial remarks reflecting his surprise at the FMC’s indications and the urgency of the situation. He then requests flaps 1 and 5.

07:12:

Alt. 5,200 ft, IAS 236 kt, 8 NM from RWY 21.

The captain continues reading the descent list, which had been interrupted, saying: “Autobrake on 2, landing data, approach briefing review”.

07:12:28

Alt. 4,400 ft, IAS 220 kt, 7 NM from RWY 21.

Canaries Approach transfers UX196 to the Lanzarote TWR.

07:12:41

Alt. 3,800 ft, IAS 210 kt, 6,1 NM from RWY 21.

The FO requests flaps 10.

07:12:52

Alt. 3,400 ft, IAS 202 kt, 5 NM from RWY 21.

The captain informs Lanzarote TWR that they are lined up on the runway 21 final. They are cleared to land on runway 21, wind from 280° at 08 kt, QNH 1,014.

07:13:12

Alt. 2,600 ft, IAS 189 kt, 4 NM from RWY 21.

The captain lowers flaps to 15. The FO requests “landing checklist down to flaps” and announces disengaging the autopilot. The captain is then heard reading the landing checklist.

07:13:30

Alt. 2,100 ft, IAS 183 kt, 3 NM from RWY 21.

The FO is heard saying “I’m going for it, I’m going to try lowering it... cause it seems to me that we’re going around”.

07:13:40

Alt. 1,700 ft, IAS 180 kt, 3 NM from RWY 21.

The “approaching minimums” automatic call-out sounded. The FO then says “landing in sight”. The captain replies, “OK”. Immediately after, the “minimums” automatic call-out sounded.

07:13:45

Alt. 1,600 ft, IAS 180 kt, 2 NM from RWY 21.

The FO asked for flaps 25.

07:13:56

Alt. 1,300 ft, IAS 177 kt, 2 NM from RWY 21.

The FO is heard struggling and then requests flaps 30. The captain tells him to wait a couple of knots so as to let the airspeed drop to the maximum allowable for flaps 30.

07:14:07

Alt. 900 ft, RA 690 ft, IAS 178 kt, 1 NM from RWY 21, vertical speed (V/S) 2,000 ft/min

The “SINK RATE, SINK RATE” caution sounded.

The captain says “it’s all right” and then informs lowering flaps to 30.

07:14:20

Alt. 500 ft, RA 420 ft, IAS 177 kt, V/S 1,900 ft/min.

The “SINK RATE, SINK RATE” “PULL UP; PULL UP” warnings sounded.

The FO says “we’ll keep it there, ok?”.

07:14:27

Alt. 300 ft, RA 250 ft, IAS 176 kt, V/S 1,700 ft/min.

The “TOO LOW TERRAIN” “SINK RATE” cautions sounded.

07:14:30

Alt. 200 ft, RA 200 ft, IAS 174 kt, V/S 1,600 ft/min, above RWY 21 threshold.

"TOO LOW TERRAIN, TOO LOW TERRAIN" caution sounded.

07:14:34

RA 115 ft, IAS 173 kt, v/s 1,500 ft/min, over runway.

"SINK RATE" "TOO LOW TERRAIN", "TOO LOW TERRAIN" cautions sounded.

07:14:47

IAS 157 kt, GS 158 kt.

Sound of contact with runway.

07:14:52

GS 137 kt.

The captain says, "Autobrake disarm!".

07:15:00

GS 96 kt.

The captain tells the FO to "apply reversers!".

07:15:01

The TWR controller activated the alarm on seeing that the airplane is overshooting the runway.

07:15:07

GS 51 kt.

Sound of airplane colliding with row of lights embedded at the end of the runway.

07:15:09

GS 40 kt.

Sounds of collision with beacons.

7:15:14

GS 8 kt.

Sound of engines spooling in reverse.

07:15:27

The captain transmits, "Lanzarote Europa 196...".

The TWR controller replies, "Sending you firefighters Air Europa".

07:15:34

The chime of the intercom is heard.

07:15:48

The captain tells the FO to "cut the engines and turn on the APU, ok?".

07:16:

The captain told the purser on the intercom to come to the cockpit so that he can explain the situation.

07:16:17

A call from a firefighting truck is heard on the TWR frequency: "Roger tower, on our way to the rendezvous point."

07:16:24

The FO is heard lamenting the event and blaming the reversers.

07:17:29

The captain requests an external ladder to disembark the passengers and confirms there are no injured onboard.

1.7.2. *Braking performance. FDR data*

Figure 3 shows the pressure (in psi) reached in the brake system as commanded by both the autobrake and by the pilots via the brake pedals. The magenta line (bottom) represents the right brake and the blue line (top) the left.

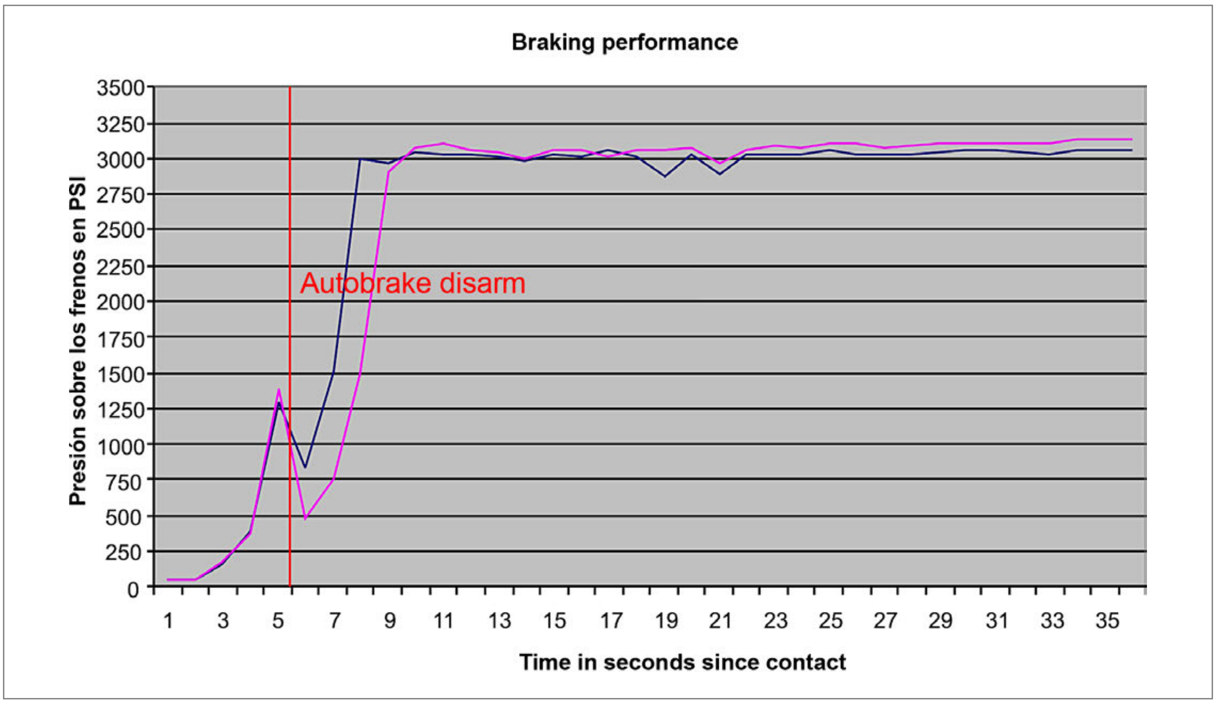


Figure 3. Braking performance during landing run

The airplane stopped 28 seconds after the landing gear made contact with the runway surface.

Figure 4 uses positive values to represent the negative longitudinal acceleration (deceleration) attained as a result of the braking action, as recorded by the FDR at ¼ second intervals.

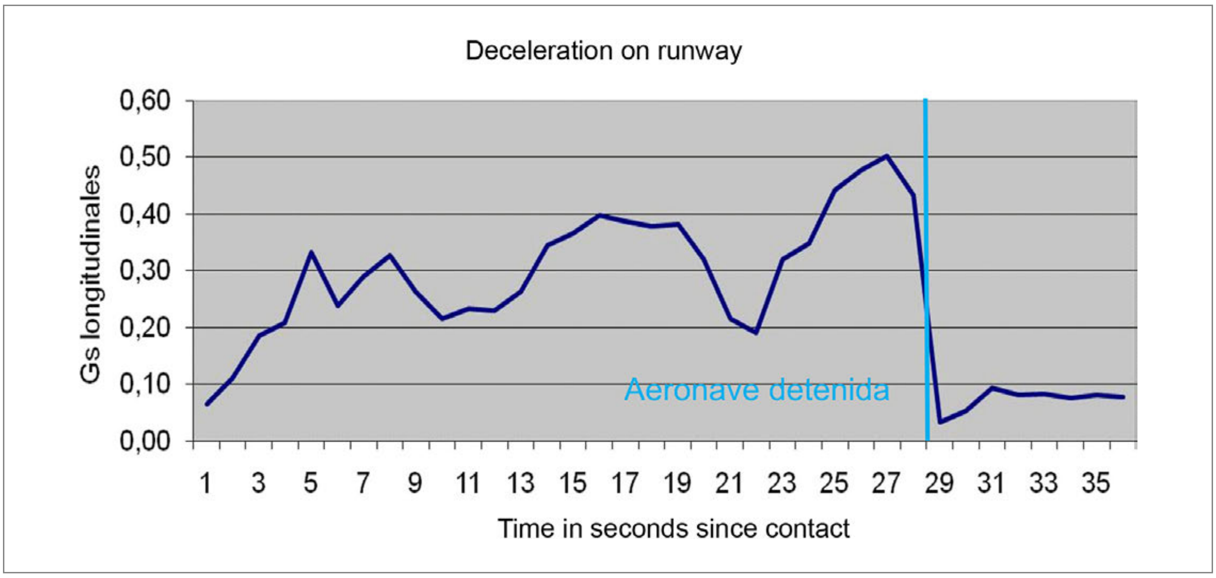


Figure 4. Deceleration during landing

Experience and an analysis of flight recorder data shows that smooth braking yields values of up to 0.2 g. Between 0.2 g and 0.4 g is normal braking, with anything above 0.4 g being hard braking that is uncomfortable to the passengers. During the first 13 seconds of the landing run, while the airplane's speed was still high, the braking efficiency varied between the low values typical of normal braking and values corresponding to smooth braking. It then increased, though it dropped during a 2 to 3 second period, reaching the highest values at the end of the run.

1.7.3. *Engine performance. FDR data*

Figure 5 shows the values of N1 (bottom curves in magenta for the no. 1 engine and indigo for the no. 2), N2 (top curves in purple for the no. 1 engine and brown for the no. 2) and TLA (throttle lever position) (bottom curves in straight segments, yellow for the no. 1 engine and blue for the no. 2) from the moment of touchdown until the end of the landing run.

As shown in the graph, five seconds after contact was made with the runway surface, the N1 and N2 engine parameters start to decrease without any change to the position of the throttle levers (TLA). As noted in 1.3.2, this is because the engines transitioned from approach idle to ground minimum idle. This transition is complete six seconds later. When the crew selects maximum reverse thrust, it takes the engines on the order of ten seconds to achieve this commanded maximum reverse thrust.

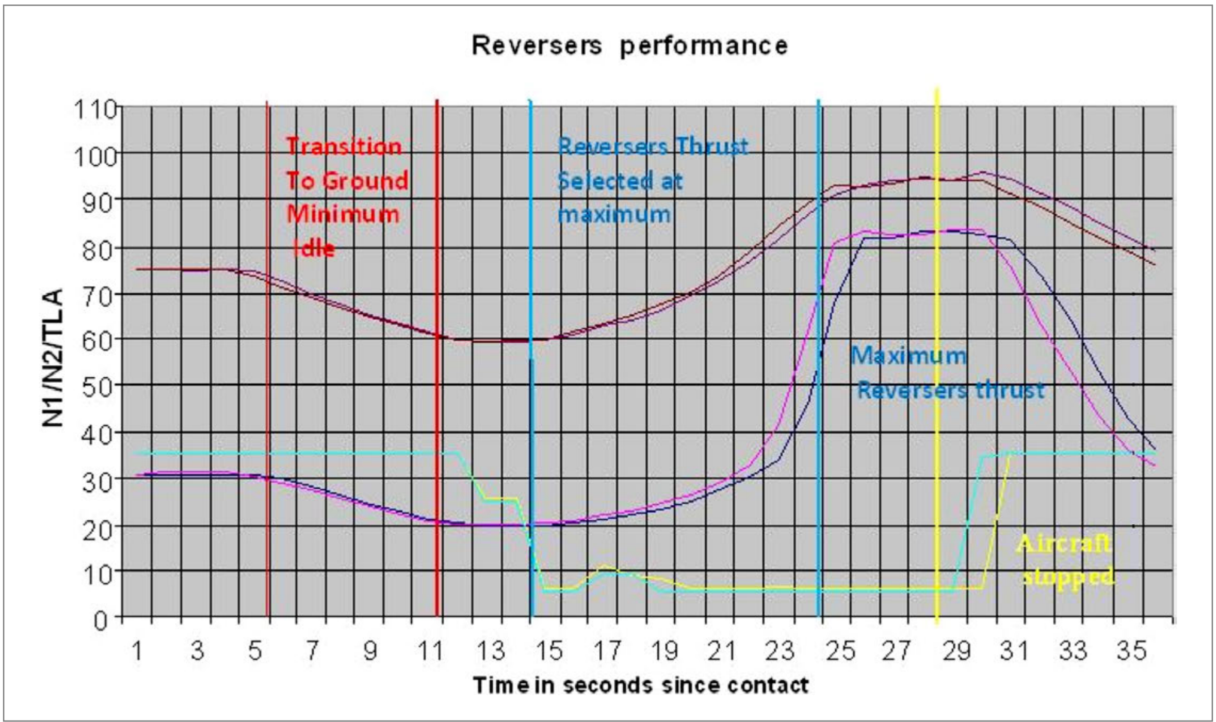


Figure 5. Engines performance during landing – reversers thrust

1.8. Organizational and management information

Air Europa has an Air Operator Certificate (AOC), which includes an instructional program approved by the DGAC that incorporates CRM training.

Air Europa also has an IOSA (IATA Operational Safety Audit) certificate, which requires defining concrete operational policies on specific aspects, such as stabilized approach, handling warnings from the GPWS system or those received above the runway landing area, among others.

In compliance with European regulations (EU-OPS), the company used an FDM/FOQA (Flight Data Monitoring/Flight Operational Quality Assurance) monitoring program that involves the routine analysis of DFDR recordings to monitor for any deviations from previously defined reference values that take place during fleet operations. This allows for the detection of abnormal events, such as flap overspeeds or EGPWS warnings during landings, as well as for an evaluation of the corresponding pilot reaction.

In the introduction to Part B of the Air Europa Operations Manual (OM), reference is made to other manuals, such as the airplane manufacturer's FCOM (Flight Crew Operating Manual) and FCTM (Flight Crew Training Manual), and to internal manuals, like the ROM (Reduced Operations Manual).

The B737 ROM features the company's procedures specific to its B737 fleet. This manual states that Air Europa's standard procedures shall be the same as Boeing's, unless modified by the ROM, OM or a memorandum.

1.8.1. *General approach procedures*

In its company procedures for its B-737 fleet, Air Europa specifies that, as a general norm, the speed at the initial approach fix (IAF) shall be 210 ± 10 kt, and that the final course shall be intercepted with the flaps at 5°.

It indicates that the final approach fix (FAF) or its equivalent shall be crossed with the landing gear down, flaps 15° and at the speed corresponding to this flaps setting.

It also states that when approaching 1,000 ft above aerodrome level (AAL), landing flaps shall be selected and the landing checklist and "vital items" shall be completed.

1.8.2. *Air Europa policy on unstabilized approaches*

Air Europa has a policy on unstabilized approaches that is based on internationally accepted standards and on the recommendations issued by Boeing, the manufacturer.

The flight safety department periodically informs crews on unstabilized approaches detected via reports and charts generated as part of its FDM/FOQA programs. This is intended to promote awareness among crews and have them abort landings (execute go around maneuvers) in these cases. This policy of ensuring stabilized approaches is also reinforced during periodic refresher training.

The stabilized approach criteria, as specified in internal document ROM 737, are as follows:

"As a general rule, descent velocities in excess of the following shall be avoided:

2,500 ft/min below 5,000 ft HAT
1,500 ft/min below 3,000 ft HAT
1,000 ft/min below 1,000 ft HAT

All approaches are to be stabilized below 1,000 ft HAT (height above touchdown) in instrument meteorological conditions (IMC) or 500 ft HAT in visual meteorological conditions (VMC). The following criteria shall be met for an approach to be considered stabilized:

- The airplane is on the proper approach course
- Only small heading and pitch changes are required to maintain this course
- The airplane's speed is not greater than Vref + 20 KIAS or less than Vref
- The airplane is in the proper landing configuration
- The maximum descent rate is 1,000 fpm. If an approach requires a descent rate above 1,000 fpm, this shall be noted in the briefing so that the approach is not mistakenly considered as being unstabilized
- The thrust setting is appropriate for the configuration
- The briefing and checklists are complete
- For ILS CAT I approaches, the maximum localizer or glide slope deviation shall be one dot. For CAT II/III, it shall be the expanded display strip for the localizer.
- For visual approaches, the wings shall be level on final approach when within 300 ft HAT.

Once an approach is started, it shall be interrupted or a go around maneuver shall be carried out if any of the following occur:

- There is confusion among the crew or there is a break in the coordination required among its members
- There is uncertainty regarding the airplane's position
- The checklists are completed late or the crew is overloaded with work
- There is a malfunction that can compromise the normal progress of the approach
- The approach altitude, speed, glide slope, path or configuration becomes unstable
- ATC orders changes that result in a hasty or unstabilized approach

- The required visual reference is not present at the decision altitude/height (DA/DH) or at the minimum decision altitude/height (MDA/MDH).
- Whenever any other circumstance exists that warrants not continuing with the approach."

Further along in the procedure, when at 500 ft AAL in VMC, the pilot monitoring (PM) or not flying shall:

- Call out "FIVE HUNDRED" if the approach is stabilized
- Turn on the landing lights and the runway turnoff lights
- Call out "FIVE HUNDRED, NOT STABILIZED, GO AROUND" if the approach is not stabilized.

1.8.3. *Company policy on location of touchdown point*

The B737 ROM specifies that the landing must be firm, centered and within the touchdown zone.

The published airplane performance data considers standard practice having the airplane fly over the threshold at 50 ft and then performing a 1,000-ft flare maneuver.

The manufacturer's FCTM regards a standard landing as occurring within 1,000 and 2,000 ft of the threshold. This same document recommends paying special attention to flying over the threshold with enough margin, meaning that contact with the runway should not occur within the first 1,000 ft of runway.

An excessively long landing is not specifically considered among the scenarios in which the company recommends or requires a go around. Nor is there any record of the Operations Department having engaged in campaigns specifically aimed at having landings take place within a specific part of the runway.

1.8.4. *Company policy on go arounds after touchdowns*

In its training, Air Europa considers, since November 2008, the go-around up to 50 ft (15 m) over the runway threshold, though the rejected landing is not considered, that is, the performance of a go around maneuver once contact is made with the runway.

In its FCTM, Boeing mentions that some operators and national civil aviation authorities consider this maneuver, but it has not developed specific procedures in this regard, as it believes that the normal go around procedures are sufficient.

The aircraft's FCTM does mention, however, that once the reverse thrusters have been actuated, the airplane must be brought to a complete stop.

1.8.5. *Procedure for handling EGPWS warnings and the FDM program*

Air Europa's B737 ROM refers to the FCOM and the QRH for handling the messages from the EGPWS.

In Boeing's FCOM and QRH, a distinction is made between two types of GPWS messages:

- *Ground Proximity Caution*, which includes SINK RATE and TOO LOW TERRAIN, the corrective action for which is for the pilots to correct the flight path or the configuration.
- *Ground Proximity Warning*, which includes the PULL UP warning. These require an immediate go around.

As part of its Flight Data Monitoring/Flight Operational Quality Assurance (FDM/FOQA) program, the airline logged and classified all approaches during which the EGPWS issued any type of warning.

The messages issued by the EGPWS have a direct relationship with unstabilized approaches. In particular, messages of the type SINK RATE, PULL UP, TOO LOW GEAR and TOO LOW FLAPS correspond to situations that are explicitly typified within the definition of an unstabilized approach (excessive descent rate or inadequate low-altitude configuration). Said messages were classified based on the height above ground at which they were issued (above 1,000 ft, between 500 and 1,000 ft, and below 500 ft).

As regards inappropriate configurations, the program also tracked the number of approaches in which the crew was late in configuring the flaps for landing "late landing flap setting".

Three levels of severity were defined based on the altitude at which the final configuration was reached. A *Low* severity was assigned when the flaps were configured below 700 ft, *Medium* when below 500 ft, and *High* when below 400 ft.

There is no record of the company having identified any systematic deficiency as a result of analyzing the results of this program, either due to repeated occurrences of these situations or to improper crew reactions when such situations did occur, that required the taking of corrective measures.

1.8.6. *Company procedures for controlled rest on the flight deck*

The general section of the Operations Manual includes and regulates the operator's policy on controlled rest on the flight deck (8.3.10.3), as required by EU OPS Regulations[2].

[2] Appendix 1 to OPS 1.1045 specifies that point 8.3.1.0 of the Operations Manual must define the procedure for the controlled rest of the flight deck crew.

Its contents are based on European standards (ACJ OPS 1.310) published by the JAA (ACJ – Advisory Circular Joint). The goal of these controlled rests is to combat sudden fatigue.

To achieve this, members of the crew may be relieved of their onboard duties for a period of time during which said members may sleep. Such periods can only be utilized during flight phases with a low workload and cannot be planned prior to the flight.

According to the company's Operations Manual, this rest period must meet the following conditions:

a) It must not exceed 45 minutes, so as to limit any sleep period to approximately 30 minutes.
b) After this period a recovery period of 20 minutes must elapse, during which the pilot that just took a controlled rest must not be left alone at the controls.
c) In the case of a two-pilot crew, the captain must inform the purser that a member of the flight crew is going to take a controlled rest and when said period terminates. Intercom contact must be established every 20 minutes between the crews of the flight deck and passenger cabin. The purser must ensure that the crew member is alert following his rest period.
d) A minimum of 20 minutes must elapse between two rest periods so as to overcome the effect of sleep inertia and allow for a proper briefing.
e) If necessary and time permitting, a pilot can have more than one rest period on long-duration flights.
f) Periods of controlled rest must finish at least 30 minutes prior to the top of descent.

1.9. Additional information

1.9.1. *Crew statements*

During the investigators' interview of the crew, the captain recalled that the Lanzarote ATIS indicated runway 03 as being in use, but that they did a briefing for 21, arguing in favor of the time saved when arriving from the north, while recognizing the greater difficulty involved due to the higher approach slope.

The captain noted his extensive experience operating out of Lanzarote, though less from runway 21. As for the FO, he reported having landed on runway 21 a couple of times.

They recalled having captured and confirmed the VOR during their approach to 21, noting that its gradient is much higher than normal.

They remembered lowering the gear and the speedbrake ahead of time to reduce speed and that the approach was not comfortable due to the environment.

They remembered lowering the flaps gradually, being careful not to exceed the maximum extension speeds, as a result of which, on occasion, they had to wait until they reached the appropriate limits.

Initially neither pilot remembered what the reference speed was, though later the pilot stated that it was 175 kt or less.

They remembered that the entire approach took place in good visual conditions and that everything was fine when they reached the minimums. A bit later, however, the color variations they saw on the runway made them realize that it was wet.

When asked about the use of the PAPI, they replied that they barely used it, but they recalled that at the start of the approach, all the lights were white and that later they saw one or two red lights.

The captain recalled that the airplane floated longer than normal during the flare and that they flew over a section of runway, which is why he changed the autobrake setting from 2 to 3 and, seeing how little runway was left, changed it again to MAX.

From the point of contact the captain noticed the airplane was not decelerating properly, though he noticed some improvement when stepping on the brakes. He also put his hands on the reversers to verify they were at maximum. He called out the lighting of the "autobrake disarm" light and then reminded the FO to increase reverse thrust.

Upon reaching the end of the runway he ruled out the possibility of leaving via the taxiway due to their high speed and continued straight to the stopway.

Neither pilot recalled any fault of any of the airplane's systems during the approach or any alerts, warnings, or red or amber lights.

Once the airplane stopped, the captain considered the possibility of backing it out using reversers or towing it, but his priority at all times was disembarking the passengers.

Through his open window he told the firefighters that there was no emergency onboard the aircraft and of his intention to disembark the passengers using the stairs.

1.9.2. *References to informing of runway condition in the Air Traffic Regulations*

In the Air Traffic Regulations (RCA in Spanish), Book Three, Chapter 4, Flight Information Service, Article 3.4.3 – Broadcasts of Flight Information Service for Operations, Point 5 – ATIS Broadcasts Intended for Arriving and Departing Aircraft, states:

> "ATIS broadcasts containing information for both arrivals and departures shall include the following information in the order indicated: a) ...... f) significant conditions of runway surface and, when appropriate, braking efficiency"

Book Four, Navigation Services Procedures, Chapter 9, Messages from Air Traffic Services, which lists the requirements involving air traffic messages, specifies:

> "4.9.4.3.4. Messages containing information on aerodrome conditions.
> [...]
> 4.9.4.3.4.2. Information regarding water on the runway must be conveyed to all interested aircraft at the controller's initiative using the following terms:
>
> DAMP - there is a noticeable color change to the surface due to moisture.
>
> WET - the surface is soaked but there is no standing water.
>
> WATER PATCHES - there are visible patches of standing water.
>
> FLOODED - there is an extensive visible patch of standing water."

The RCA, Book Four, Navigation Services Procedures, Chapter 5, Aerodrome Control Services, Article 4.5.8, Point 2, states that the essential information provided regarding aerodrome conditions is to include, among others, water on the runways, taxiways or platform.

1.10. Safety measures already taken by the operator

The operator reported that it has adopted safety measures as a result of the investigation and findings associated with this incident.

In June 2009, it modified its Flight Data Monitoring/Flight Operational Quality Assurance program to include specific monitoring of unstabilized approaches below 500 ft.

These approaches are classified based on 17 parameters and result in three levels of severity, depending on how many of these parameters exceed a preset limit. A low severity is assigned when two values exceed the limits, medium when 3, 4 or 5 values are involved and high when more than 5 values are exceeded.

In October 2009, in the B-737 ROM, it was modified the policy for the reverse thrust use, in point 2.9, in order to avoid possible wrong misinterpretations of its use and application, as it has been restricted so as to obtain a bigger fuel saving.

2. ANALYSIS

2.1. The descent correction made in order to land on runway 21

The FO, who was the PF, had programmed the descent into the FMC in accordance with the flight plan. They would follow standard arrival (STAR) TERTO 1P, then the VOR

DME ILS approach to runway 03 in order to "do the maneuver calmly in LNAV", as he was heard explaining during the approach briefing. The ATC clearance was in keeping with the flight plan filed.

When, at 07:05:06, the captain decided to change plans to land on runway 21 instead of 03, the airplane was at 21,000 ft and descending. It had 70 NM to drop altitude and reduce its speed. The average descent rate planned and maintained until then had been 300 ft per NM, slightly below normal, probably due to the wind prediction input into the FMC. Boeing, in its FCTM, considers a standard descent rate as 1000 ft every 3 NM, or 330 ft/NM. With the change in plans, landing on runway 21 decreased the landing distance by 23 NM, meaning the airplane was only 47 NM away from the runway 21 threshold. This required an immediate increase in the descent rate to 446 ft per NM, or a 50% increase in the rate maintained until then.

The table below was made using the radar traces provided by the Canaries Control Center and already used in Section 1.7 – Flight data recorders. The fourth column shows the airplane's altitude divided by its distance to the runway 21 threshold, yielding the descent rate necessary, in ft/NM, to reach the runway 21 threshold. Notice how the required descent rate kept increasing gradually until it reached an impractical extreme.

ATC Time	Altitude (1,013) in ft	Distance to runway 21 threshold in NM	Descent rate required to reach runway 21 threshold
07:05:51	19,500 ft	42.3 NM	460 ft/NM
07:07:30	15,500 ft	32.4 NM	478 ft/NM
07:09:30	10,100 ft	21.1 NM	479 ft/NM
07:10:30	8,000 ft	15.3 NM	523 ft/NM
07:11:30	6,700 ft	10.7 NM	626 ft/NM (near aIIF)
07:12:52	3,700 ft	5.3 NM	698 ft/NM (over FAF)
07:13:52	1,500 ft	2.1 NM	714 ft/NM
07:14:10	1,100 ft	1.3 NM	846 ft/NM
07:14:20	800 ft	0.9 NM	888 ft/NM
07:14:30	400 ft	0.3 NM	1,333 ft/NM
07:14:40	200 ft	0.1 NM	2,000 ft/NM

2.2. Instability on approach

In its company procedures, Air Europa states that as a general norm, the speed upon arriving at the initial approach fix (IAF) will be 210 ± 10 kt, and that the final course will be intercepted with flaps 5 when intercepted within 12 NM of the threshold. Flight

UX196 intercepted the final course practically at the IAF at 253 kt and with the flaps fully retracted.

The company dictates that the final approach fix (FAF) is to be crossed with flaps 15 and at the maneuvering speed associated with that flaps position. In this case, it was crossed with flaps 10 at 209 kt.

The approach card specifies a minimum altitude for passing through the FAF of 2,000 ft, meaning a rate of descent (ROD) of 6.48%.

Passing through the FAF at 3,400 ft however, as happened in this case, requires an ROD of 11%, meaning the descent rate would have to be almost 2,000 ft/min.

The company's stable approach criteria recommend descent rates less than 1,500 ft/min below 3,000 ft and less than 1,000 ft/min below 1,000 ft. The average descent rate maintained by UX196 below 3,000 ft was 1,900 ft/min and 1,800 ft/min in the last 1,000 ft.

The same stable approach criteria require that at 500 ft, in VMC, speed not exceed Vref + 20 kt. In this case, the speed was Vref + 43 kt, a speed that was maintained until the flare. Contact with the runway was made at Vref + 23 kt.

The descent rate should not exceed 1,000 ft/min below 500 ft. In this case, it averaged 1,650 ft/min between 500 ft and the flare.

The briefing should be complete, but in this case no briefing was held for the approach to this runway (21).

The company's procedures require that the PM (pilot monitoring), in this case the captain, calls out "FIVE HUNDRED, NOT STABILIZED, GO AROUND" on an unstabilized approach upon reaching 500 ft. This call out was not made.

At this altitude, the EGPWS was issuing "SINK RATE" and "PULL UP" warnings, as noted in the next section, though the crew did not interpret the situation or the warnings as a reason for initiating a go around.

The operator had in place a policy for unstabilized approaches that was based on international standards and on Boeing's recommendations. It defined when an approach was regarded as unstable and recommended going around when such a situation arose.

The operator also had a monitoring mechanism in place, based on the routine study of flight recorder data (mainly EGPWS messages) as part of its FDM/FOQA program, that was intended to detect situations directly involving unstabilized approaches.

As was noted during the investigation, however, the crew's statements and the information provided by the operator revealed that the operator's policy of conducting a go around when the approach became unstable was not sufficiently ingrained in its crews.

As a result of the above, and in order to have the operator advance in its implementation of a stabilized approach policy, a safety recommendation is issued in this regard.

2.3. Response to EGPWS warnings

The EGPWS warnings were issued repeatedly between 900 ft and 100 ft over a 28-second time span. There were caution messages ("SINK RATE" and "TOO LOW TERRAIN") and warning messages ("PULL UP, PULL UP").

The B737 QRH defines the procedures to follow in response to both message types.

Caution messages require correcting the flight path, though, in general, if visual conditions prevail and the absence of any collision danger is confirmed, the approach can continue.

Warning messages require more forceful action to stabilize the aircraft while monitoring altitude and vertical speed.

The first SINK RATE caution took place at a radar altitude (RA) of 686 ft when the descent rate was 2,027 ft/min. The captain said "it's all right".

At a RA of 420 ft the SINK RATE caution sounded again, along with PULL UP PULL UP. The descent rate then was 1,883 ft/min. This time, the FO told the captain, "Let's keep it there, ok?" No reply was heard from the captain.

At a RA of 210 ft, practically over the runway 21 threshold, mode 4B was activated on the EGPWS with the TOO LOW TERRAIN caution. Even if the lever had been set at 30, the flaps would only have been lowered to 25 due to the flap load relief mechanism that protects the flaps from an overspeed situation. The crew did not react to this caution, the cause for which it probably did not identify. The IAS at the time was 174 kt. If this speed had been below 159 kt, the system, by design, would have issued the TOO LOW FLAPS caution, which would have helped the crew to identify the reason for the caution.

2.4. The point of contact with the runway

It is estimated that the point of contact upon landing was more than 1,300 m away from the runway 21 threshold; that is, more than halfway down the runway, with a remaining distance of some 1,160 m (taking into account the 60-m stopway).

The aircraft performance for a dry runway landing and 30° flaps with autobrake yields a minimum landing run in excess of 900 m.

The safety margin for the landing, thus, was low, especially considering the moisture that was present on the runway surface.

2.5. The landing run

Appendix B shows a not-to-scale estimate of the airplane's path on the runway and of the most relevant events that occurred during the landing run.

2.5.1. *The use of brakes*

The landing took place at 07:14:47 with flaps 30° and the autobrake selected to the MAX position. When contact was made, a vertical acceleration of 1.41 g was recorded, enough to instantly activate the air/ground selector. The spoilers deployed normally right away and the autobrake sequence initiated.

Five seconds after touchdown the autobrake was interrupted and the "Autobrake Disarm" light energized. The captain immediately detected this and called it out, as recorded by the CVR. Both pilots fully depressed the brake pedals without delay, but 2.5 seconds elapsed until hydraulic pressure in the brake system built up to the same value it had at the time of the interruption, and 3 seconds until the deceleration reached the value of -0.33 g it had prior to the interruption.

Between 9 and 12 seconds after touchdown, the deceleration decreased almost by half, to –0.22 g, while maximum pressure (3,000 psi) was applied to the brakes. The most likely explanation is that the airplane was crossing the area of runway close to the 1,000 ft marks for runway 03 where the rubber buildup is extensive and the coefficient of friction lower, especially if the surface is wet or damp, as the crew had noted and as was verified during the investigation.

Between 13 and 18 seconds after touchdown there was a notable increase in deceleration, reaching values of –0.4 g. This probably coincided with a deviation of the airplane to the right of the runway, where there was less rubber buildup.

Then, between seconds 18 and 21, the deceleration dropped drastically once again, coinciding perhaps with the airplane's passage over the white paint marks that signal the runway 03 threshold and which tend to be very slippery when wet.

The runway hit the edge at the end of the runway 22 seconds after touchdown at a ground speed (GS) of 51 kt, crossing into the stopway. It is in this area where the acceleration of the engines in reverse took place and was heard.

The increase in reverse thrust once more intensified the deceleration, though the airplane went past the 60-m long runway 21 stopway before finally coming to a stop on the asphalt extension of the runway, which has a more pronounced descending gradient than the stopway. The aircraft came to a full stop 28 seconds after the initial contact with the runway.

2.5.2. *Use of reversers*

Five seconds after touchdown, the engine went into "ground minimum idle" mode, its revolutions starting a gradual but considerable descent, with N1 going from 31% to 20% and N2 from 75% to 59%.

The "approach idle" mode in the engines is selected automatically when the flaps are in a landing configuration, since the higher % RPM for N1 and N2 lowers the engine spin-up time in the event that a go around is required. The engine's ability to respond is degraded, therefore, when they transition to "ground minimum idle".

Twelve seconds after touchdown, as the airplane was traveling at 96 kt (GS) with barely 200 m of runway left, the captain realized they had not engaged the reversers, which he announced to the FO with the phrase "reversers!". The FO immediately moved the thrust levers to the maximum reverse thrust position. By design, the levers cannot reach this position immediately. They remain locked in the "Detent No. 1" position (reverse thrust idle), as shown on the graph, until the deflectors are physically open 60% of the way. That is why the maximum reverse thrust position on the lever was reached three seconds after the reversers started to deploy, with the airplane traveling at a GS of 84 kt.

From the "ground minimum idle" position it took the engine a further 10 seconds to accelerate to 83% of N1, the maximum value reached, by which time the airplane had practically stopped.

In its FCTM, Boeing mentions that once the reversers are activated, the airplane must be brought to a complete stop.

The degradation in the engine's capacity to respond when the pilots delay either in engaging the reversers upon landing or in applying thrust to execute a go around must be known and taken into account by crews. A safety recommendation is issued to the manufacturer in this regard so that it emphasizes this fact in its manuals.

2.5.3. *Available options*

This occurrence took place in a pressure-free environment in which the crew had several options available to correct the chain of events that resulted in the incident.

The runway in use at the time of the incident was 03. Landing on 21 was approved by Canaries Approach because the traffic so permitted it at the time. There were no obstacles to requesting runway 03 once more and proceed as originally planned.

Once lined up on the approach, another option was to carry out a go around, in light of the gradually worsening situation.

The company's procedures explicitly state that the pilot monitoring must require a go around at 500 ft if the approach is not stabilized. The approach was obviously unstabilized, as evidenced by the EGPWS warnings.

The captain was based out of the Canaries and admitted having considerable experience flying out of Lanzarote, where most flights are from the north. With runway 03 being preferred, it is very common when arriving from the north, as in this case, to request the right downwind leg to this runway so as to save time and fuel. Both pilots were undoubtedly aware of this alternative and had it available as a viable option the entire time they were on final for runway 21.

The option of requesting a 360° to lose altitude was another option that was no doubt known by both pilots.

A rejected landing was also a valid alternative on this occasion. The speed remained above V2 until five seconds after touchdown. The excess energy would have allowed the aircraft to regain altitude almost immediately. The rejected landing maneuver must never be attempted once the reversers are actuated.

2.6. CRM and Human Factors

2.6.1. *Fatigue*

Fatigue could have been a contributing factor to the performance of both pilots. By the time of the incident they had logged 10 hours and 30 minutes of flight time, all of it in the minimum performance phase of the circadian rhythm.

The incident coincided with sunrise. The FO noted it at 07:06:29, while waiting for ATC's reply to their request to use runway 21. Sunrise is considered a critical moment for anyone who has spent the night awake. It is a time at which the "human clock" must synchronize itself with the "real" solar clock, thus multiplying the feeling of fatigue.

Having the pilots alternate taking brief breaks during cruise flight is generally recognized as beneficial to preventing excess fatigue. It is also necessary, however, to have time to recover from the effects of a nap before fully regaining one's abilities. In this case, the captain had been resting in his seat shortly before the top of descent, with the decision to request the change of runway taking place only eleven minutes after he woke up.

2.6.2. *The leadership of the captain*

The interview held and the CVR recording reveal that at no time did the captain touch the controls or manipulate the autopilot, despite being aware of the gradually worsening situation after the change of plans.

The roles of PF and PM for each leg of the flight were decided during the dispatch. These roles were strictly observed. The possibility of switching them was not considered when the circumstances dictated doing so in order to improve the efficiency of the team. During the approach that resulted in the incident, the FO was at times overwhelmed by work while the captain limited himself to telling the FO that he had to descend more without actually intervening directly.

The captain undoubtedly noticed that the FO could not adapt properly to the circumstances and that the situation was worsening, and yet he decided to maintain his role and not take control of the airplane himself.

The captain made every decision. At no time did he ask the FO his opinion. He decided to request the runway change, he decided to have the FO continue flying and he decided to continue the approach in spite of the presence of a multitude of indications that suggested or required that the maneuver be stopped. He eventually decided to land, increasing the autobrake setting to MAX instead of ordering a go around when he saw they were landing too fast in the middle of a wet runway.

2.6.3. *The FO's lack of communication assertiveness*

The FO's long and meticulous briefing for runway 03 is evidence of his preoccupation over the detailed preparation of the operation, as confirmed by his custom of arriving early to prepare the flight.

When the captain decided to request the change in runway, the FO did not exhibit the necessary assertiveness to tell him that he needed time to prepare for this new approach. Initially, he may have been unaware of the challenge posed by this change in plans, though it became evident little by little that his abilities were being overtaxed and that he was uncomfortable with the new situation, not having time even to read the chart for 21 and hold the relevant briefing. His lack of assertiveness to tell the captain that he did not agree with what he was being forced to do is undoubtedly a contributing factor to the genesis of the incident.

2.6.4. *Deficient communications*

The FO is a young man whose manner of expression is colloquial and relaxed, one that in general, as is heard on the CVR, gives the impression of a confident and self-assured individual. This personal characteristic could have erroneously made the captain think that the FO agreed with the decisions he had made and had the situation under control.

This fact, along with the deficient assertiveness of the FO, contributed to create a situation in which bad communications prevailed between the pilots during the approach, one that could have been resolved using proper CRM communication techniques.

2.6.5. *The FO's dependence on the FMC*

The FO exhibited an excessive dependence on the FMC. This kept him from assessing the overall situation and recognizing the airplane's excess energy. The change in plans required increasing the descent rate and stopping the airplane. He instead focused on reprogramming the FMC without daring to anticipate any actions. Following ATC's clearance to change the runway, he lost almost a minute and a half reprogramming the FMC.

After 07:10:33, he is heard saying "VNAV... and we're off. What's this say? 'Unable next altitude' OK!" Then, at 07:11:51, he made a series of colloquial statements that reflected his surprise at the FMC's indications and the urgency of the situation.

2.6.6. *The effectiveness of CRM training*

Both pilots had received CRM training, having worked with trainers well versed in concepts such as leadership and decision making, assertiveness, communication, fatigue, situational awareness, teamwork, etc. And yet, many of those topics that were theoretically discussed and studied during the training courses now seem to have contributed to the cause of this incident.

Though Air Europa has an approved CRM program, the actions of the crew during this incident reveal a deficient application of CRM techniques. So as enhance the CRM skills of flight crews, a safety recommendation is issued to the operator to improve and reinforce the CRM training of its crews.

2.7. Information broadcast to aircraft

The ATIS broadcast did not include information on the condition of the runway surface which, even though it was no longer raining, had been wet or damp for at least an hour. The information relayed by the tower controller with the landing clearance also did not include any mention of the condition of the runway surface.

The condition of the runway surface is not always easy for arriving crews to ascertain. The runway is only visible during the day and under the cloud cover if the sky is overcast. Even then its status may be concealed by existing lighting conditions or by the presence of weather phenomena.

While the RCA establishes the requirement of Air Traffic Services to provide aircraft with information on the condition of runways, it seems common for this information to not be relayed at Spanish airports.

Spain's Aviation Safety Agency (AESA) was asked about its interpretation of the RCA articles mentioned in 1.9.3. In AESA's opinion, said information "on the condition of the runway surface" should be provided to aircraft by the relevant air traffic station (aerodrome control tower). Specifically, the presence of water on runways, taxiways or platforms should be conveyed to aircraft using the appropriate means (NOTAM, ATIS, and use of signals or by air traffic services personnel whose job it is to inform aircraft).

In this case, the condition of the runway surface (wet or damp) was noticed by the crew prior to landing. This notwithstanding and in keeping with the aforementioned reasons, a safety recommendation is issued to centers that supply flight information so that they provide information to arriving flights concerning important aspects of the condition of the runway both via the ATIS as well as with the landing clearance.

3. CONCLUSIONS AND CAUSES

3.1. Findings

- The crew was properly licensed to operate the aircraft.
- The rest period prior to the flight was in accordance with existing regulations.
- The controlled rest period was in keeping with Operations Manual requirements in terms of its duration, but it did not adhere to the minimum time that must elapse between its conclusion and the start of the descent.
- The airplane was airworthy and there were no malfunctions of any system that affected the progress of the incident.
- ATC personnel were professional, courteous and cooperative at all times.
- The runway was partially wet, a fact the crew was not informed of either by the ATIS or by the tower controller at the time of the landing.
- The FO was the PF on this leg. At no time did the captain manipulate the airplane's controls, the AP or the FMC, except during the final braking maneuver.
- The FO held a briefing in which he laid out his plan to land on runway 03 "calmly" in LNAV.

- The captain decided to request a change in the runway without consulting the FO, though it was the latter who physically requested the change from ATC.
- After requesting runway 21, the FO realized that he was unprepared should ATC grant the request.
- The FO did not immediately identify the airplane's excess energy as a result of the runway change and was over reliant on the FMC calculations.
- The captain insisted repeatedly that the FO increase the descent rate without himself taking any actions to that end.
- The descent did not increase sufficiently to achieve a glide slope appropriate for landing on runway 21.
- The approach became unstable vertically, according to the company's definition.
- The captain, acting as PM, omitted the 500-ft call out specified in the OM as company practice and which requires the PM to demand a go around if the approach is unstable.
- The crew did not respond adequately to the EGPWS warnings that were issued between the altitudes of 900 ft and 80 ft.
- During the flare, the captain decided to change the autobrake setting to its MAX position when he realized that the landing was going to be very long and that the runway was wet.
- The airplane landed some 100 m past the runway halfway point, that is, 1300 m from the 21 threshold at a speed of Vref + 23.
- The autobrake was canceled involuntarily when a brake pedal was inadvertently depressed. The captain noticed this immediately, with both pilots responding by depressing the brake pedals.
- The reversers were not engaged until 12 seconds after touchdown, but the engine's acceleration from "ground minimum idle" was so slow that it did little to brake the airplane.
- The airplane exited the end of the runway at a GS of 51 kt and crossed the stopway before coming to a stop one meter away from the threshold 03 jet blast barrier.
- The airport's emergency services reacted efficiently, reaching the airplane quickly, though their services were not required.
- The damage was limited to the airplane's tires and to two beacons situated beyond the end of the runway.
- The airport remained closed until 10:15, three hours after the incident occurred.

3.2. Causes

The cause of the incident was a high-energy unstabilized approach followed by a landing with excessive speed, 1300 m past the threshold, with a wet runway. In addition, neither the autobrake nor the reversers was used efficiently.

A contributing factor to the incident was a combination of deficiencies involving several aspects of CRM (Crew Resource Management).

4. RECOMMENDATIONS

REC 50/11. It is recommended that the operator, Air Europa, review and enhance the CRM training of its flight crews to raise their awareness of the importance of CRM skills and that it increase its monitoring and evaluation of its crews' abilities in this field.

REC 51/11. It is recommended that Air Europa stress the applicability of its policy on stabilized approaches, and in particular the requirement to go around when the approach does not meet stability criteria.

REC 52/11. It is recommended that the aircraft manufacturer include in the appropriate aircraft documentation (FCTM, AFM, etc.) a warning on how delaying an input to the throttles after landing, either to activate the reversers or to execute a go around, can result in a corresponding delay in engine response.

REC 53/11. It is recommended that AENA establish the necessary procedures so that the stations responsible for supplying flight information to arriving aircraft provide relevant information on the condition of the runway surface.

APPENDIX A

CARTA DE APROXIMACIÓN POR INSTRUMENTOS-OACI | ELEV AD 47 | APP 129.300 TWR 120.700 GMC 121.800 ATIS 118.625 | LANZAROTE VOR RWY 21

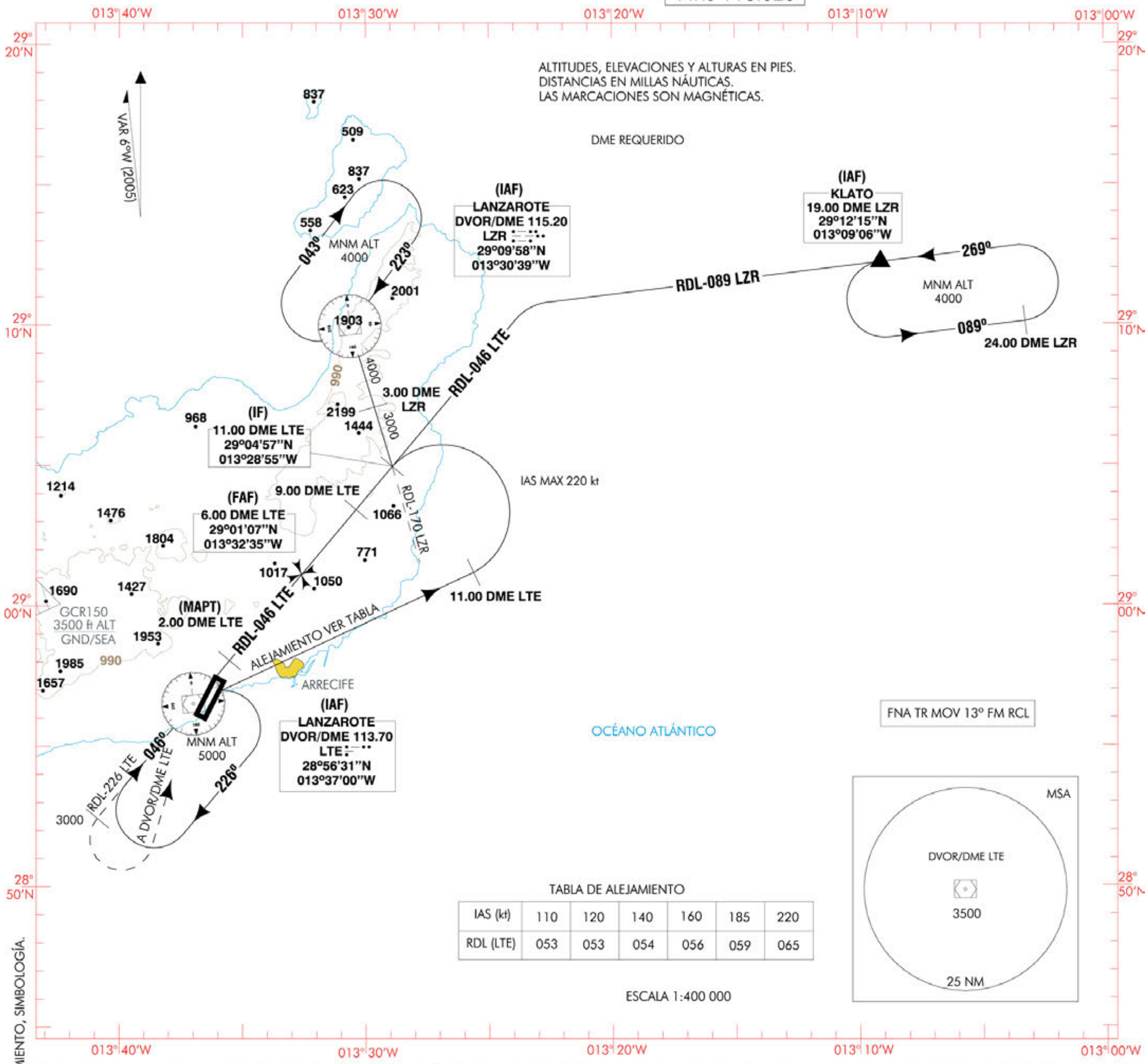
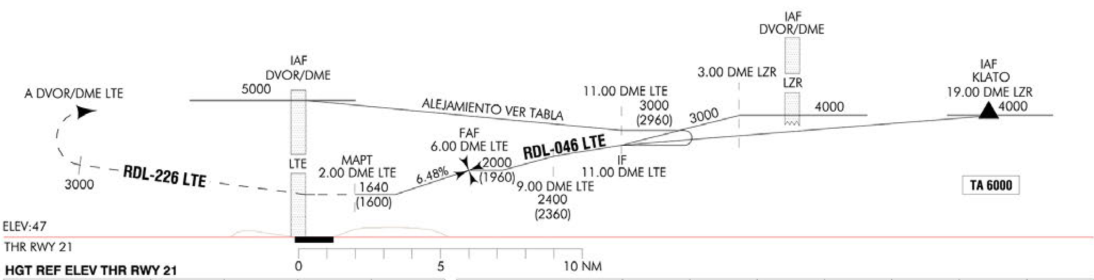


TABLA DE ALEJAMIENTO

IAS (kt)	110	120	140	160	185	220
RDL (LTE)	053	053	054	056	059	065

FRUSTRADA: SUBIR DIRECTO AL DVOR/DME LTE PROCEDER POR RDL-226 LTE HASTA ALCANZAR 3000 ft. VIRAR A LA IZQUIERDA DIRECTO AL DVOR/DME LTE SUBIENDO A 5000 ft PARA INTEGRARSE A LA ESPERA.



HGT REF ELEV THR RWY 21

OCA/H		A	B	C	D
STA	2.5%	1640 (1600)			
En circuito (H) sobre 47		1640 (1600)	2350 (2310)	2450 (2410)	2470 (2430)

GS	kt	80	100	120	140	160	180
	min:s						
FAP-MAPT: 4.00 NM	min:s	3:00	2:24	2:00	1:43	1:30	1:20
ROD: 6.48 %	ft/min	525	657	788	919	1051	1182

ALT/HGT/DME ( ) FNA

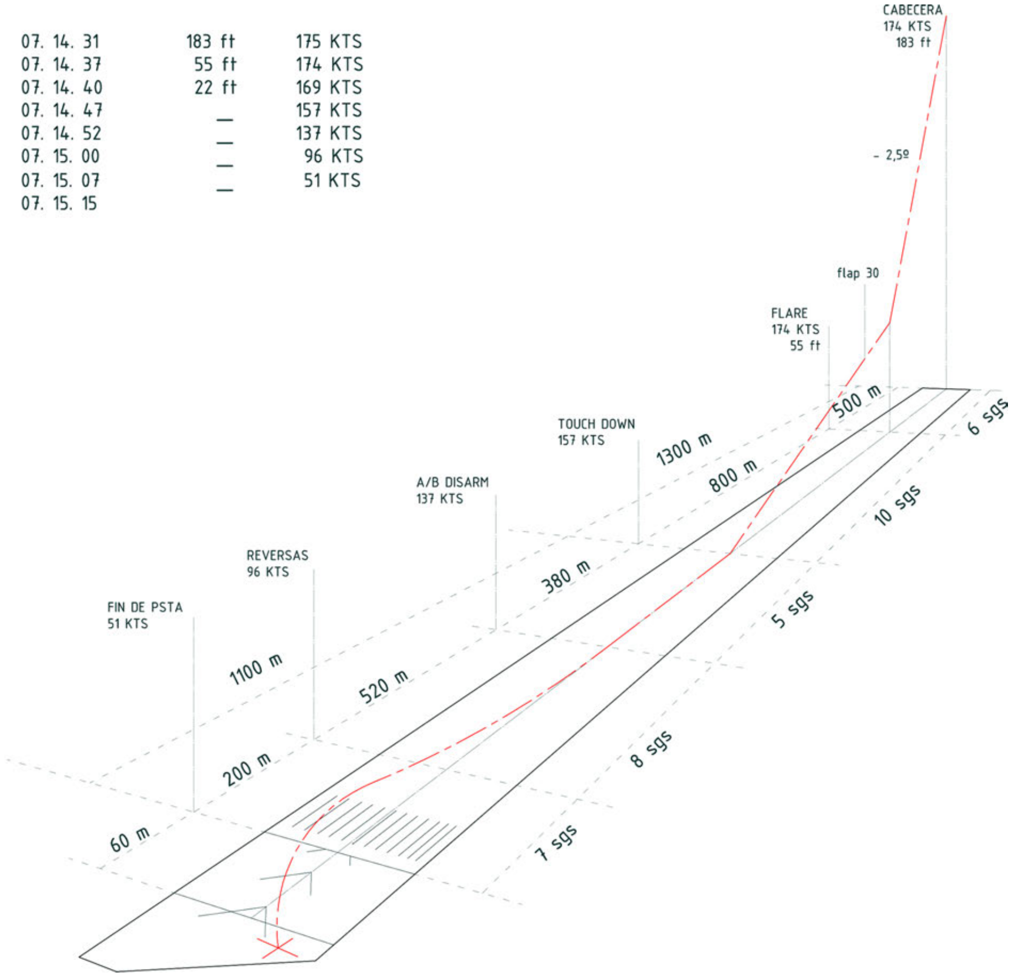
13 DME	12 DME	11 DME	10 DME	9 DME	8 DME	7 DME	6 DME	5 DME	4 DME	3 DME	2 DME	1 DME

CAMBIOS: DECLINACIÓN MAGNÉTICA, DENOMINACIÓN PROCEDIMIENTO, SIMBOLOGÍA.

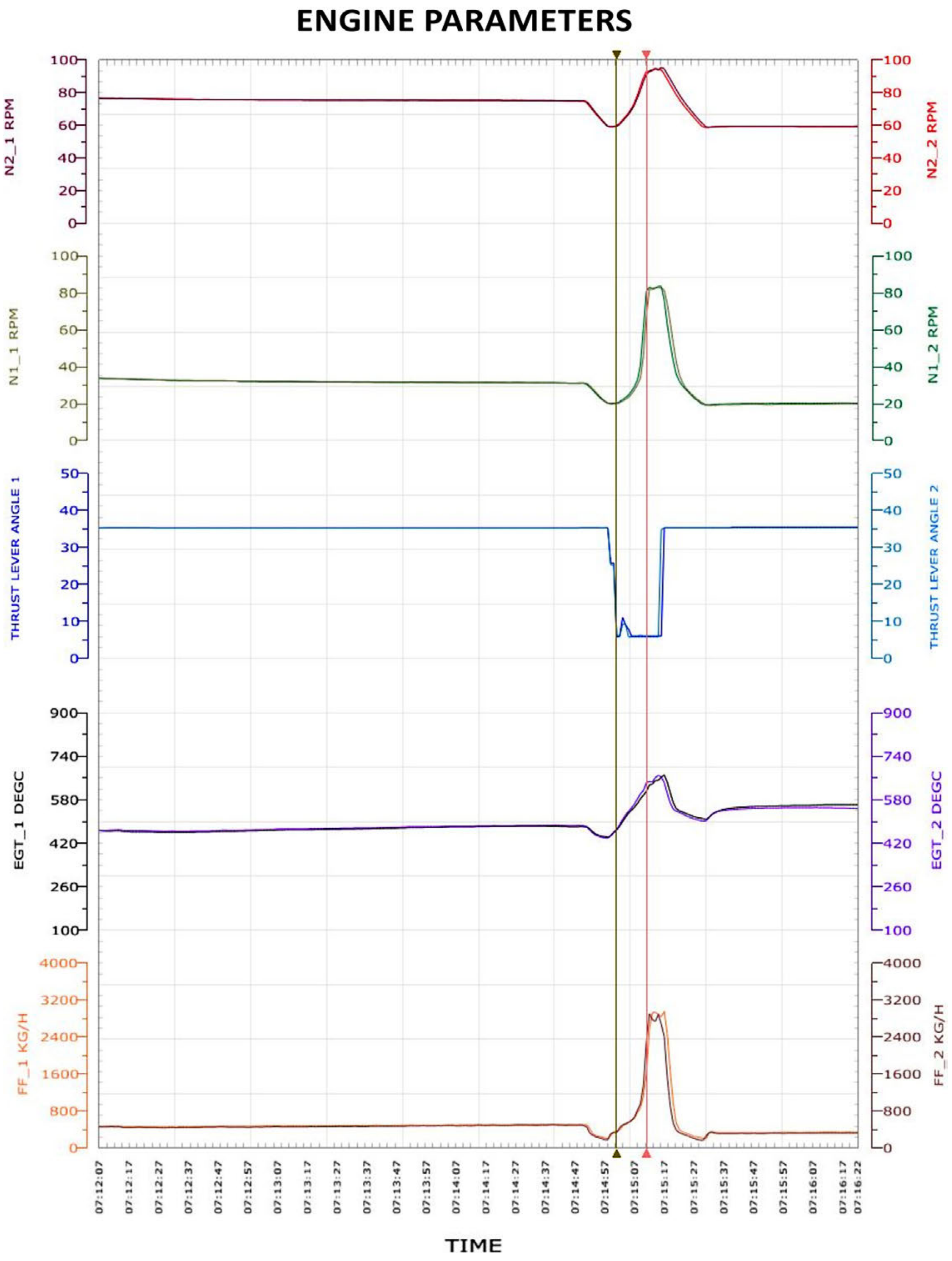
WEF 17-JAN-08 (AIRAC AMDT 16/07) AIS-ESPAÑA AD 2-GCRR IAC/6

APPENDIX B

cabecera 21	07. 14. 31	183 ft	175 KTS
flare	07. 14. 37	55 ft	174 KTS
flap30	07. 14. 40	22 ft	169 KTS
touch down	07. 14. 47	—	157 KTS
A/B disarm	07. 14. 52	—	137 KTS
reversas	07. 15. 00	—	96 KTS
colisión fin pista	07. 15. 07	—	51 KTS
stop	07. 15. 15		



APPENDIX C
Engine parameters


ENGINE PARAMETERS
N2_1 RPM
N2_2 RPM
N1_1 RPM
N1_2 RPM
THRUST LEVER ANGLE 1
THRUST LEVER ANGLE 2
EGT_1 DEGC
EGT_2 DEGC
FF_1 KG/H
FF_2 KG/H
TIME