CIAIAC

COMISIÓN DE
INVESTIGACIÓN
DE ACCIDENTES
E INCIDENTES DE
AVIACIÓN CIVIL

Report A-011/2006

Accident involving
a B737-600 aircraft,
registration 7T-VJQ,
at Seville Airport,
on 18 March 2006

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DE ESPAÑA

MINISTERIO
DE FOMENTO

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SECRETARÍA DE ESTADO DE TRANSPORTES
COMISIÓN DE INVESTIGACIÓN DE ACCIDENTES E INCIDENTES DE AVIACIÓN CIVIL

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Foreword

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

In accordance with the provisions in Article 5.4.1 of Annex 13 of the International Civil Aviation Convention; and with articles 5.5 of Regulation (UE) n° 996/2010, of the European Parliament and the Council, of 20 October 2010; Article 15 of Law 21/2003 on Air Safety and articles 1, 4 and 21.2 of Regulation 389/1998, this investigation is exclusively of a technical nature, and its objective is the prevention of future civil aviation accidents and incidents by issuing, if necessary, safety recommendations to prevent from their reoccurrence. The investigation is not pointed to establish blame or liability whatsoever, and it's not prejudging the possible decision taken by the judicial authorities. Therefore, and according to above norms and regulations, the investigation was carried out using procedures not necessarily subject to the guarantees and rights usually used for the evidences in a judicial process.

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

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

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Abbreviations

00°	Degrees
00 °C	Degrees centigrade
A/T	Autothrottle
ACC	Area Control Center
AEMET	State weather agency
AFDS	Automatic Flight Director System
AFE	Above Field Elevation
AFS	Automatic Flight System
AGL	Above Ground Level
AIP	Aeronautical Information Publication
AOA	Angle Of Attack
APP	Approach control
ARP	Airport Reference Point
ATC	Air Traffic Control
ATIS	Automatic Terminal Information Service
CAS	Calibrated Airspeed
CAT 1	Category 1 ILS
CRM	Crew Resource Management
CSN	Cycles Since New
CTR	Control zone
CVR	Cockpit Voice Recorder
DFDR	Digital Flight Data Recorder
DH	Decision Height
DME	Distance Measuring Equipment
DOT	Measure of deviation from LOC or GP
DOW	Dry Operating Weight
EFIS	Electronic Flight Instrument System
EGPWS	Enhanced Ground Proximity Warning System
FCC	Flight Control Computers
FCOM	Flight Crew Operating Manual
FCTM	Flight Crew Training Manual
FDR	Flight Data Recorder
FL	Flight Level
FMS	Flight Management System.
FOD	Foreign Object Debris
Fpm	Feet per mile
ft	Feet
FWD	Forward
GLS	GNSS Landing system
GND	Ground
GNSS	Global Navigation Satellite System
GP	Glide path. ILS component
GPWS	Ground Proximity Warning System
g's	Acceleration due to Earth's gravity
GSPD	Ground speed
h	Hours
HAT	Height Above Touchdown
HDG	Magnetic course or Heading
IAF	Initial Approach Fix
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
IR	Inertial Reference
IRS	Inertial Reference System
IVV	Inertial Vertical Velocity
kg	Kilogram(s)

Abbreviations

kt	Knot(s)
LAT	Lateral Acceleration
LEZL	ICAO designator for Seville
LGB	Landing Gear Beam
LH	Left Hand
LOC	Localizer. ILS component
LON	Longitudinal acceleration
LT	Local Time
LW	Landing Weight
m	Meter(s)
METAR	Aviation routine weather report
Min	minutes
MLG	Main Landing Gear
MSN	Manufacturer Serial Number
N1	Spool 1 engine rpm's
N2	Spool 2 engine rpm's
NDB	Non-directional Beacon
NG	New Generation
NLG	Nose Landing Gear
NM	Nautical Miles
NOSE	Nose gear
NOTAM	Notice To Airmen
NTSB	National Transportation Safety Board – U.S.A.
NW	Northwest
P/N	Part number
PAPI	Precision Approach Path Indicator
PF	Pilot Flying
PNF	Pilot Not Flying
QNH	Altimeter sub-scale setting to obtain airport elevation above sea level when on the ground during takeoff and landing
RA	RadioAltitude
RH	Right Hand
ROD	Speed or Rate Of Descent
RVR	Runway Visual Range
RWY	Runway
S	South
S/N	Serial number
SE	SouthEast
SPECI	Special aviation weather report
SSE	South-SouthEast
TAF	Terminal Aerodrome Forecast
TAS	True AirSpeed
TDZ	TouchDown Zone
TL	Transition Level
TOW	Take Off Weight
TSN	Time Since New
TWR	Aerodrome control tower
UTC	Coordinated universal time
VERG	Vertical acceleration
VMC	Visual Meteorological Conditions
VOR	VHF Omnidirectional Range
VREF	Landing reference speed
WSW	West- southwest
ZFW	Zero Fuel Weight

Synopsis

Owner and operator:	AIR ALGERIE
Aircraft:	B737-600, registration 7T-VJQ
Date and time of accident:	18 March 2006, at 10:34 LT[1]
Site of accident:	On runway 27 at Seville Airport
Persons on board:	101 passengers and 6 crew
Type of flight:	Commercial transport – Non-scheduled – International passenger
Date of approval:	26th September 2011

Summary of accident

After a normal flight from the departure airport, Oran (Algeria) the aircraft started a direct approach to runway 27 at Seville (Spain) under stormy weather conditions with heavy rains. The resulting touchdown was very hard and caused the right main landing gear leg to collapse. An emergency evacuation was conducted using the emergency ramps. There were no serious injuries to any of the aircraft's occupants and there was no fire.

[1] Even though Oran and Seville are in different time zones, they share the same official time. That is why all times in this report are expressed in the common local time. Only in the tables showing the DFDR data in the appendices are times expressed in UTC, and then only in the columns so labelled.
To obtain UTC time, subtract one hour from local time (LT).

1. FACTUAL INFORMATION

1.1. History of the flight

At 09:36 on Saturday, 18 March 2006, aircraft 7T-VJQ took off from Oran Airport en route to Seville Airport. The non-scheduled Air Algerie DAH2652 flight was due to arrive at Seville Airport at 10:30. The aircraft, a Boeing B737-600 NG, was being operated by its owner, Air Algerie. Its cockpit crew consisted of a pilot and copilot, aided by a passenger cabin crew of four flight attendants. The pilots had started their activity for that day on that flight. Onboard the aircraft were 101 passengers and there were no empty seats.

Flight DAH2652 was dispatched from Oran with a takeoff weight of 56,850 kg. Its expected landing weight in Seville was 54,350 kg (307 kg below the maximum allowable landing weight of 54,657 kg). At the time of landing, there was about 5,500 kg of fuel remaining in its tanks.

The weather in Seville at the time of arrival was forecast to be stormy with variable rain and winds. The visibility, reduced by the heavy rain, was in excess of 2,000 m (RVR) at the runway 27 threshold.

The runway in use at Seville was RWY-27, which had CAT I visual and precision radio navigation landing aids.

According to the data recorded on the flight, the flight had taken a NW course following its departure from Oran that took it over Malaga before continuing on its way to its destination over the east of Seville. While in autopilot, the aircraft captured the LOC (ILS localizer) as it neared Seville, at a distance of 11 NM from the runway 27 threshold (see maps in Appendix A).

Flight DAH2652 was cleared to land on runway 27 some nine minutes prior to its arrival time and before descending below the transition level, which was at 7,500 ft above sea level.

The control tower reported the wind about three minutes prior to landing, which at that time was from 240° at 15 kt. The runway was wet and it was raining heavily. The crew was told to proceed on course to Seville at their discretion and in accordance with their procedures.

With the tower's clearance, they captured the glideslope early, far above the 2,000 ft specified in the published AIP procedure and descended along the ILS glideslope without significant deviations from the LOC and GP until they were below 1,000 ft AGL and with the runway in sight. Established on the glideslope with the gear down and flaps 30°, they disengaged the autopilot at about 700 ft and shortly thereafter they started to climb above the glideslope. The aircraft then descended to the runway at very high descent rates. The EGPWS SINK RATE and PULL-UP warnings sounded shortly before touchdown.

The airplane landed in the middle of an intense rain storm. Personnel in the control tower saw a flame or glow on the right side of the aircraft. During the hard impact with the runway at the aiming point, some 300 m beyond the threshold, the right main gear leg collapsed, pivoting backwards and partially detaching. The crew was able to maintain steering control of the aircraft, which came to a stop after a 900-m landing run. Full reverse thrusters were used to decelerate the airplane. The entire landing roll took place on the paved runway surface. Only at the end of the run did part of the airplane, the right wingtip, touch the ground in an area beyond the paved asphalt.

After coming to a stop, and lacking the support from the right leg, the aircraft was being held up by its left leg and right engine, which is forward of the airplane's center of gravity, as a result of which the aircraft tilted backwards until the tail touched the ground during the final seconds of braking.

There was no fuel leak and no fire. The captain gave the evacuation order, which was carried out using the four doors on both sides of the airplane.

Due to the final nose-up pitch of the aircraft, the front doors were at a significant height above the ground. As a result, the emergency evacuation ramps were inclined at an excessive angle that hindered the exit of the airplane's occupants.

1.2. Injuries to persons

Injuries	Crew	Passengers	Total in the aircraft	Others
Fatal				
Serious				
Minor				Not applicable
None	6	101	107	Not applicable
TOTAL	**6**	**101**	**107**	

1.3. Damage to aircraft

The right main gear leg collapsed during the landing, resulting in various fractures to the gear itself and to the supporting structure, fittings and stays on the right gear leg. There was also minor damage to the nose gear leg and to the left main gear leg.

As a consequence of the right gear collapse, there was secondary damage to the engine on that side caused by ingestion of FOD (Foreign Objects Debris) and to the flaps, cowlings and fairings, all caused as part of the aircraft dragged along the ground.

1.4. Other damage

As it scraped over the runway, the aircraft broke several runway lights.

1.5. Personnel information

1.5.1. *Pilot in command*

The pilot in command of the aircraft was 53 years of age and had an airline transport pilot license that was valid until 21/08/2006. He had a B737-NG captain rating issued on 22/07/2005, had completed his last proficiency check on 20/12/2005 and had received CRM training. At the time of the accident he had a total flying experience of 16,196 h, of which 3,100 had been on the type.

The accident flight was his first flight of the day, during which he had been the pilot flying (PF).

1.5.2. *Copilot*

The copilot of the aircraft was 48 years of age and had an airline transport pilot license that was valid until 04/04/2006. He had a B737-NG copilot rating issued on 15/01/2005, had completed his last proficiency check on 20/12/2005 and had received CRM training. At the time of the accident he had a total flying experience of 6,204 h, of which 802 had been on the type.

The accident flight was his first flight of the day, during which he had been the pilot not flying (PNF).

1.6. Aircraft information

The aircraft, registration 7T-VJQ, is a Boeing 737-600 outfitted with CFM56-7B22 engines. It was delivered to Air Algerie on 29/04/2002.

It is a new generation (NG) aircraft with full instrumentation, EFIS (Electronic Flight Instrument System), and computer-assisted flight controls (FCC – Flight Control Computers). It has a Flight Management System (FMS) and an Automatic Flight System

(AFS). The AMS has an Automatic Flight Director System (AFDS) and an Autothrottle (A/T), which allow the aircraft to land automatically.

The maintenance documentation shows that the aircraft had been maintained in accordance with the applicable maintenance program. No existing problems were found onboard that could have contributed to the accident.

1.6.1. *General aircraft information*

Manufacturer:	BOEING
Model:	B737-6D6
Manufacturer's Serial Number (MSN):	30209
Registration / State of Registration:	7T-VJQ / Algeria
Operator:	Air Algerie
Airworthiness certificate:	• Issue date: 15/05/2002 • Validity: 12/04/2006
Certificate expiry date:	12/04/06
Total flight hours (TSN):	9,300 h
Total cycles (CSN):	6,380

1.6.2. *General engine information*

	No. 1 engine (left)	No. 2 engine (right)
Manufacturer:	CFMI	CFMI
Model:	CFM56-7B	CFM56-7B
Part number (P/N):	CFM56-7B22	CFM56-7B22
Serial number (S/N):	876636	889911
Total hours:	9,473 h	9,300 h
Total cycles:	6,114	6,380

1.6.3. *General landing gear information*

	Nose gear	Left main gear	Right main gear
Manufacturer:	MENASCO	MENASCO	MENASCO
Part number (P/N):	162A1100-5	161A1100-27	161A1100-28

	Nose gear	Left main gear	Right main gear
Serial number (S/N)	MAL00250Y1115	MAL02263Y1115	MAL02264Y1115
Total hours	9,300 h	9,300 h	9,300 h
Total cycles	6,380	6,380	6,380

1.6.4. *Dispatch load sheet for accident flight*

A load sheet was prepared for the dispatch of flight DAH2652 with the following information on it:

• No. of passengers:	101	
• Total payload:	10,080 kg	
• DOW (Dry Operating Weight):	38,770 kg	
• ZFW (Zero Fuel Weight):	48,850 kg	MZFW: 51,482 kg
• Takeoff Fuel Weight:	8,000 kg	
• TOW (Takeoff Weight):	56,850 kg	MTOW: 65,090 kg
• Fuel used during flight:	2,500 kg	
• LW (Landing Weight):	54,350 kg	MLW: 54,657 kg

The airplane's center of gravity was within authorized limits.

1.6.5. *Parameters applicable to the approach and landing in Seville*

The following data for the landing operation in Seville on the day of the event were determined in accordance with the instructions in the aircraft flight manual and the applicable procedures in the Boeing operating manual for B-737 type aircrafts (FCOM – Flight Crew Operating Manual).

- The length of runway required for landing at Seville (111 ft elevation, 15 °C temperature, 10 kt tailwind and wet runway): 1,500 m.
- Reference speed on approach with 30° flaps and landing weight of 54,350 kg: VREF = 130 kt.
- Thrust required in both engines to descend 3° glideslope, with no turbulence, at the reference speed and with the actual landing weight: N1 = 50%.
- Maximum allowable pitch angle to avoid a tail strike on a level runway: 8°.
- Maximum angle of attack in landing configuration with 30° flaps and actual landing weight: AOA = 15°.
- Maximum upward deflection of elevator surfaces: 19°.
- Maximum tailwind component: 10 kt.
- Maximum wet runway crosswind: 5 kt.

1.6.6. *Description of main landing gear*

The B737-600 is equipped with a retractable gear. The legs and wheels, when retracted, are housed horizontally in the wheel wells, which are inside the fuselage and near the wing roots.

To lower the gear, the leg drops laterally downward and outward, pivoting on two trunnions until the legs reach a vertical position and are perfectly aligned with the airplane's longitudinal axis.

The two trunnions, one forward (FWD trunnion) and one aft (AFT trunnion), define the axis of rotation of the leg when retracting, parallel to the aircraft's main axis, and comprise the two main support points for the gear. A third support, which props the legs when extended, is achieved by means of a side stay, which is located between the strut and a support on the wing (reaction link). This stay is hinged such that the gear can be retracted when a hydraulic actuator is actuated, while the extended position can be locked in place to ensure the leg remains vertical.

The body of the leg, or strut, consists of a forging that includes the two trunnions, the drag stay, which stiffens the strut to keep it from bending forward and aft, and the external strut cylinder itself.

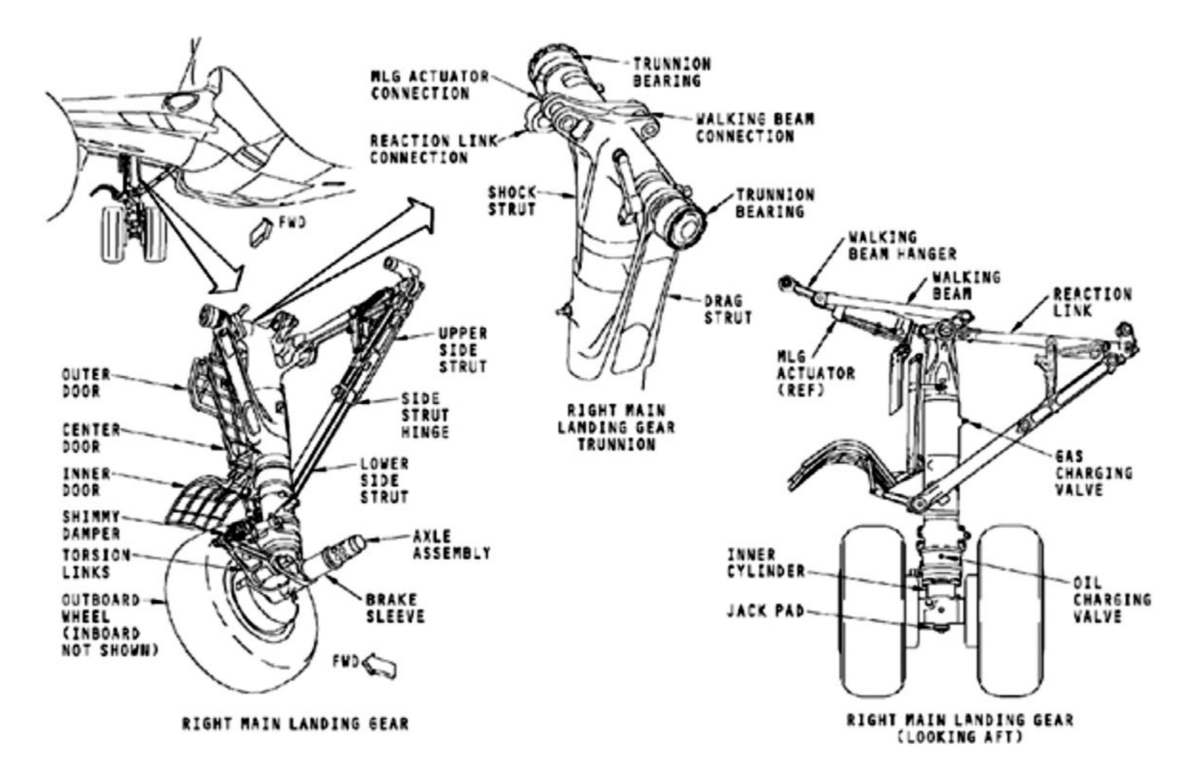


Figure 1. MLG RH

The lower part of the strut is cylinder shaped and allows for the cylinder that is inside it to move up and down in concert with the wheel axis. Both cylinders consist of an oleo-pneumatic cylinder that dissipates the energy of the airplane's impact upon landing. The wheel axis is kept extended by means of a torque link that prevents the inner cylinder from turning with respect to the outer one.

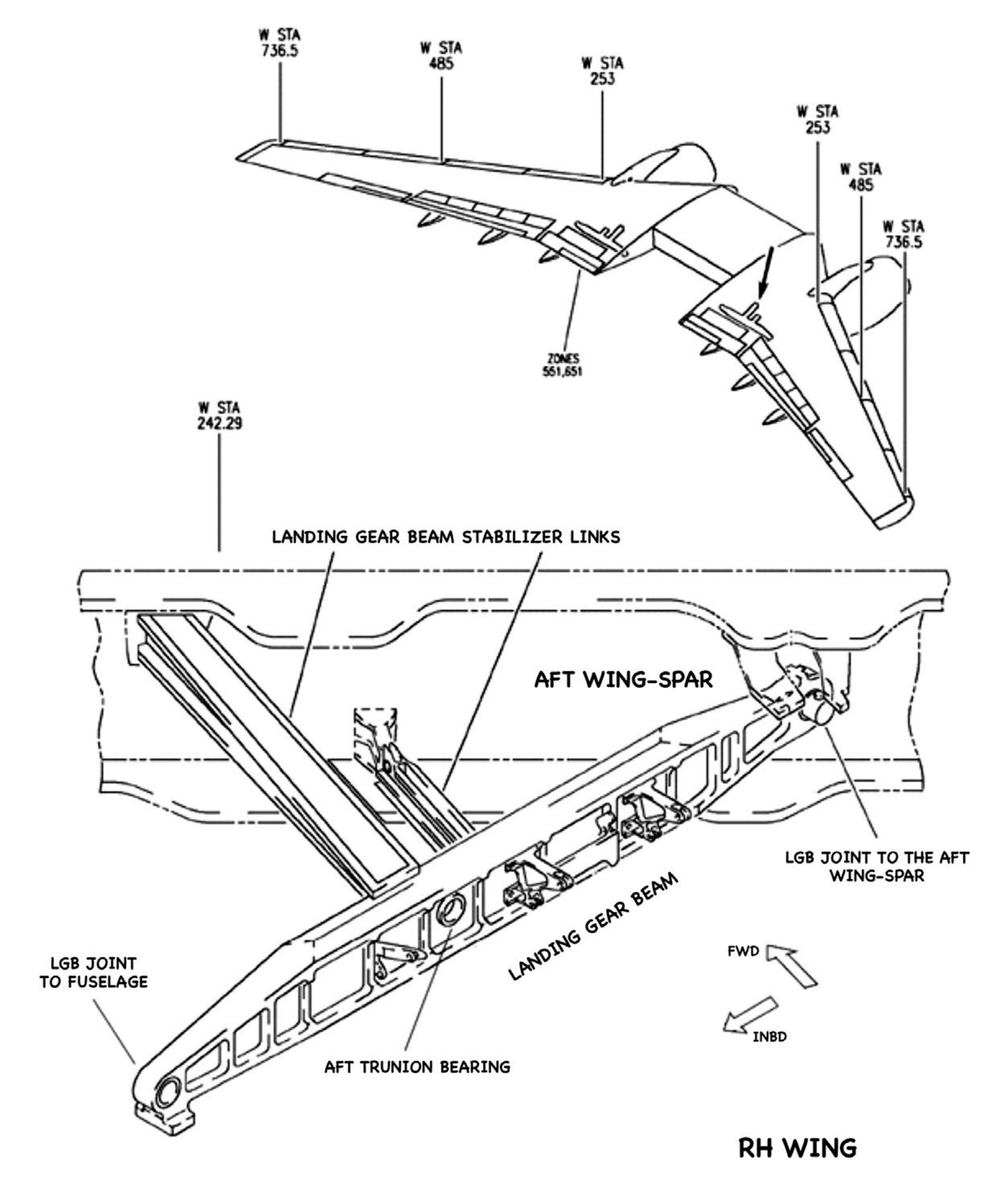


Figure 2. Aft support of MLG RH

The forward trunnion or pivot point is housed in a fitting on the aft spar that is attached to the spar by four pins.

The aft trunnion or pivot point consists of an extension of the leg forging that is housed in and pivots about a bearing located in the landing gear beam (LGB).

This horizontal beam is arranged perpendicular to the fuselage and is supported by the fuselage and by a station outboard of the beam. The LGB is further stabilized by two braces between the LGB itself and the aft beam. The swept-wing design forms a triangular structure (between the aft beam, fuselage and LGB) that confers high rigidity to the support for the aft gear trunnion.

The aft wing spar, in addition to being a key component in the airplane's primary structure, is the aft panel of the integral fuel tank. Aircraft design regulations include provisions so that in the event of an extremely hard landing, vibrations from the landing gear do not cause the tanks to lose their integrity, with the ensuing danger of leaks and fires.

In keeping with this idea, the fitting that houses the forward trunnion bearing is joined to the aft beam by means of two frangible pins. Likewise, the four attachment pins for the LGB stabilizing stays and the pin that attaches the LGB beam to the aft spar must be fusible links that protect the aft spar from failures that would affect the airtightness of the integral fuel tank.

1.6.7. *Operation of the Ground Proximity Warning System (GPWS)*

The Ground Proximity Warning System (GPWS) provides visual and aural warnings to the pilots when flying in dangerous conditions that might entail colliding with the ground. The system receives information from the navigation, altimeter, anemometer, inertial and other systems, as well as indications on the configuration of the landing gear and flaps.

Seven operating modes trigger alarms due to (1) excessive descent rate, (2) level or low ascent rate flight toward elevated terrain, (3) loss of altitude after takeoff, (4) insufficient safe separation with the terrain, (5) excessive deviation below the glide path (GP), (6) dropping below the decision height (DH) and (7) windshear.

Of particular interest to this accident are the conditions for modes (1), (5), (6) and (7).

In Mode (1) the warnings are generated based on the conditions shown in the graph in Figure 3. Thus, at an altitude of 50 ft, the SINK RATE warning is activated if the rate of descent (RoD) is 1,000 ft/min or greater. The RoD limit increases proportionately with altitude to a value of 5,007 ft/min at an altitude of 2,450 ft. If the RoD is even higher, the PULL-UP warning is triggered when the rate exceeds 1,500 ft/min at 50 ft and 1,710 ft/min if the altitude is less than 284 ft.

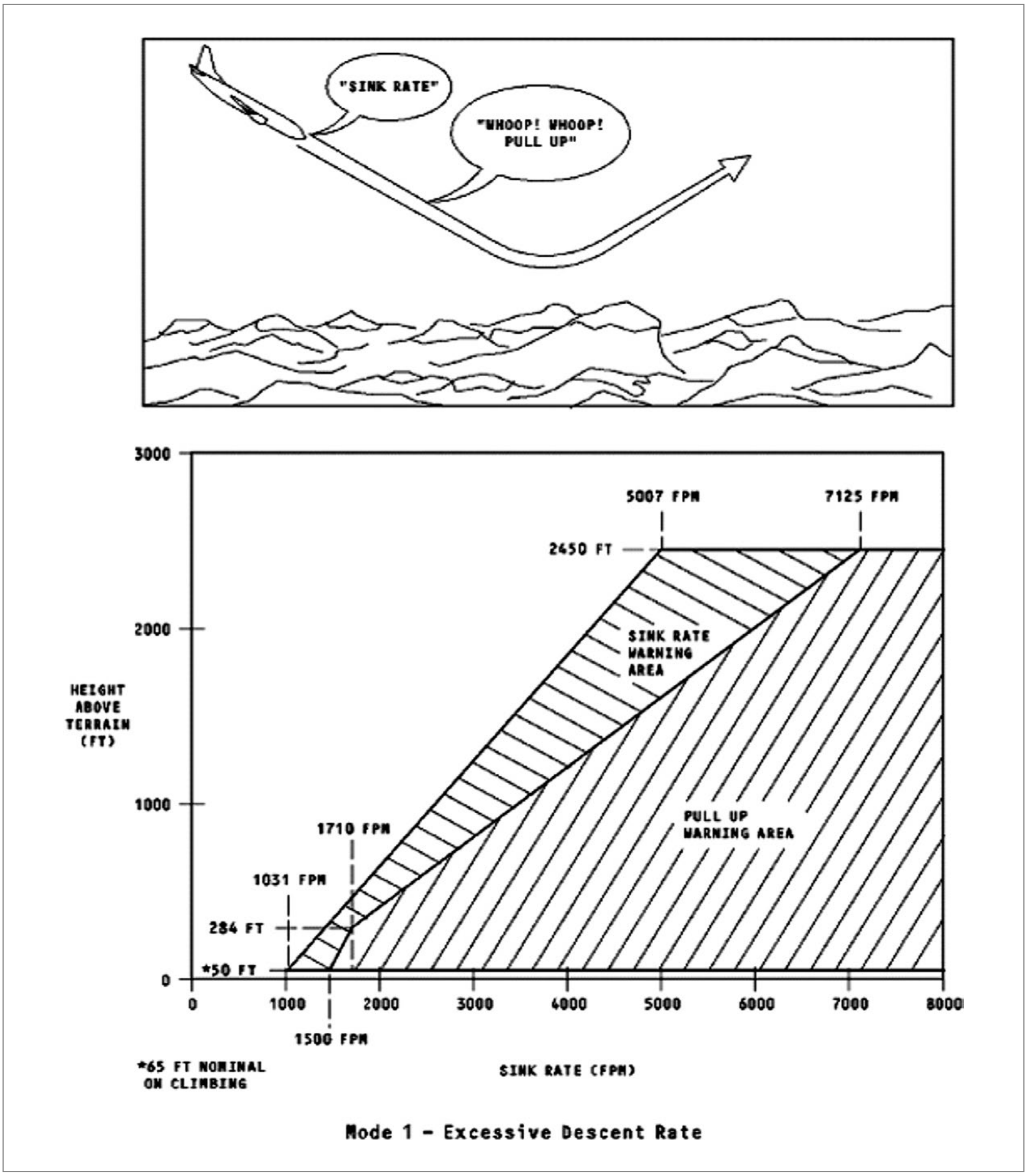


Figure 3. GPWS Mode 1

The GPWS is armed in Mode (5) when an ILS frequency is selected should the aircraft descend more than 1.3 dots below the glide path with the landing gear down at a radio altitude of between 150 ft and 1,000 ft. If the deviation exceeds two dots, the volume of the aural warning reaches its maximum value.

This warning can be inhibited if the pilot intends to fly below the glide path.

In Mode (6) warnings are issued based on the altitude of the aircraft while on approach. The GPWS announces passing through 2,500 ft, 1,000 ft, 50 ft, 40 ft, 30 ft, 20 ft and 10 ft.

The descending through 500 ft warning, "FIVE HUNDRED", is only given is the aircraft is outside the ± 2 DOT tolerance on either the localizer or glide path. The warning is also issued for approaches that vary from the ILS or for back courses.

Depending on the selection made by the pilot on the minimums switch, the system may issue the "PLUS HUNDRED" and "MINIMUMS" warnings.

In Mode (7) the GPWS issues WINDSHEAR warnings if it detects a windshear condition at a radio altitude below 1,500 ft. Windshear conditions are calculated based on wind stream components, both vertical and horizontal. Variations in vertical wind conditions are detected by comparing the signals from the angle of attack sensors, true airspeed (TAS), pitch angle and the signals from the inertial vertical speed. Variations in horizontal wind conditions are determined from changes in TAS and from the inertial references of the IRS.

The system can also give a "WINDSHEAR AHEAD" warning if it detects through the weather radar a risk of entering a windshear area.

1.7. Meteorological information

The general situation over the entire Iberian Peninsula was one of predominant low-pressure areas with southerly winds, while a cold front with frequent and persistent precipitation was affecting the west.

1.7.1. *METAR and TAF aerodrome reports*

- 10:00 METAR: Wind from 170°/11 kt gusting to 22 kt, visibility 3,000 m, storms and rain, 1 to 2 oktas of cumulonimbus at 1,500 ft and cloudy at 2,000 ft, temperature 15° and QNH 1,001.
- 10:30 METAR: Wind from 240°/11 kt gusting 22 kt, visibility 3,000 m, storms and heavy rain, scattered clouds at 800 ft, 1 to 2 oktas of cumulonimbus at 1,500 ft and cloudy at 2,000 ft, temperature 14° and QNH 1,001.
- 11:00 METAR: Wind from 170°/05 kt gusting to 16 kt and varying in direction between 140° and 240°, visibility 3,000 m, storms and rain, scattered clouds at 800 ft, 1 to 2 oktas of cumulonimbus at 1,500 ft and cloudy at 2,000 ft, temperature 13° and QNH 1,001.
- TAF issued at 05:00 for the period from 08:00 to 17:00 UTC: Wind from 160/12 kt, visibility in excess of 10 km, cloudy with clouds at 3,500 ft, temporarily from 07:00

to 16:00 UTC: 210°/14 kt gusting to 28 kt, visibility 3,000 m, storms and rain, cumulonimbus at 1,500 ft cloudy at 2500 ft.

Weather radar images show lightning storms starting in the early hours of the day over Seville province (see Appendix B).

1.7.2. *Weather situation at Seville Airport*

The most probable weather situation at Seville Airport on 18 March 2006 between 10:00 and 10:45 was as follows: very cloudy or overcast skies with low- and medium-altitude clouds between 800 and 2,000 ft, lightning and rain with strong vertical winds likely, associated with cumulonimbus clouds with tops reaching heights of 8 km at some points. The rainfall was strongest at 10:20, with a rate of 31.8 mm/h. The wind went from WSW at 10 to 15 kt at 10:30 UTC to SSE at 8 to 12 kt at 10:45 UTC. Visibility was 3,000 m and the temperature between 14 and 15 °C.

Wind readings from the runway thresholds indicated the passing of an atmospheric disturbance at around 10:30 that resulted in the wind shifting from the south at 10 or 12 kt to westerly at 17 kt and then from the SE at 2 to 12 kt, all in the course of a few minutes. The readings, recorded in ink on lined paper, allow for a qualitative analysis but are not accurate enough to conduct a consistent numerical analysis.

1.7.3. *Weather information available to the crew*

The weather information, printed at 08:00, available to the crew at the time the flight was dispatched, and which was taken from the cockpit, included the same TAF report described in 1.7.1 and a significant weather chart valid for 13:00 for that same day and with information very similar to that provided in Appendix C. In particular, the chart shows the passing of a cold front and an area over the Gulf of Cadiz, including Seville, with symbols indicating storms, heavy rain and occasional or well-separated cumulonimbus clouds at levels from 2,000 and 27,000 ft.

During the flight the crew was kept informed of changes in the weather through the ATIS broadcast. In one piece of paper taken from the cockpit is a note on the 10:00 ATIS in which the crew wrote: TL (transition level) 75, wind from 160°/12 kt, visibility 5,000 m, scattered clouds at 1,500 ft, cloudy at 3,000 ft, ambient temperature and dew point 15°/15° and QNH 1,000 mb. At 10:22, twelve minutes prior to touchdown, the CVR recorded the reception of the ATIS that warned of rainstorms.

According to the CVR, the crew was also informed of the storm situation during ATC communications. As for the wind, the TWR reported a wind of 240°/10 kt to the crew three minutes before touchdown, and confirmed the wind data as being 240°/15 kt fifty-one seconds before touchdown.

1.7.4. *Storm warnings*

The National Weather Institute (now the State Weather Agency, AEMET) has a service at various aerodromes for issuing very short-term storm warnings. This service is intended to assist in aircraft refueling operations.

This system issued a lightning warning for the Seville Airport at 10:28. At 10:38 the system issued its maximum alert.

Information on lighting impacts in the Seville area, and in particular of a strike at 10:28:01 some 5 km west of the Seville Airport reference point, was also gathered from an electricity grid operator that has a system for detecting storm cells.

1.8. Aids to navigation

On the date of the accident, the Seville Airport had navigation and landing aids that included VOR, NDB and a CAT I precision ILS for runway 27. The ILS glide path, GP, has a 3° gradient and its antenna was located 409 m to the right of the runway threshold as seen by approaching aircraft and 119 m away from the runway centerline. There is also a DME station associated with the ILS.

Complementary to the ILS there is also a visual glide path aid, namely a PAPI station, also with a 3° glide path.

No malfunctions or faults were reported with the aid and lighting systems, which are assumed to have functioned normally.

1.9. Communications

The crew of the aircraft was in contact with the Seville Area Control Center (ACC) and with the Seville Airport approach (APP) and tower (TWR) controllers.

The initial communications were routine for this type of flight. During the exchange with the ACC at 10:11:25, the crew requested to descend and they were cleared to FL250; at 10:15:25 they were cleared to descend to FL190 and to proceed directly to point ROTEX, the initial approach fix (IAF); at 10:17:27 they were cleared to descend to FL170, at 10:19:33 to FL150 and at 10:22:08 to FL130. They were then transferred to approach control.

Once in contact with APP, they were informed at 10:23:00 that they were in radar contact and were cleared to descend to 9,000 ft. A few seconds later, ATIS reported the presence of rainstorms and scattered cumulonimbus over the touchdown zone.

Shortly thereafter, APP was heard clearing a departing aircraft to go around the storm. At 10:23:58, they were cleared to descend to 4000 ft. At 10:25:07 they were cleared for ILS approach on runway 27, to head for ROTEX at their discretion and, from that point, to continue in accordance with their ILS procedures. In the three minutes that followed, the crew twice requested and was authorized to deviate at their discretion so as to avoid the storm.

At 10:30:02, the aircraft was transferred to the control tower, which authorized it to land at 10:30:49, in what would be their last communication during this event.

Shortly after touchdown, at 10:34:13, the crew of another aircraft situated at the runway 27 hold point informed the control tower that the Air Algerie flight had damaged its gear during landing.

1.10. Aerodrome information

The Seville Airport, designator LEZL, is 10 km SE of the city and is surrounded by flat terrain. The elevation of the runway 27 threshold is 111 ft. Some 20 km away from this field, and flown over by the aircraft during its approach to runway 27, are some hills and high ground with elevations of up to 750 ft in and around the towns of El Viso del Alcor and Mairena del Alcor.

The concrete and asphalt runway 09-27 is 3360 m long and 45 m wide. It is oriented along 273° magnetic and it has a 0.64% gradient at the touchdown zone. The runway has lights at the threshold, centerline and its edges and at either end. The touchdown zone or aiming point is indicated with two large rectangles painted on the pavement at either side of the runway centerline and 300 m from the threshold.

The airspace around the field consists of a CTR zone (6.5 NM circuit centered about the airport reference point, ARP) and an aerodrome traffic zone (8-km circuit centered about the ARP or smaller in radius, depending on visibility).

Special procedures for reduced visibility are in effect when the runway visual range (RVR) or visibility are below 600 m.

Appendix C shows the charts for the airport and for the ILS approach to runway 27 in effect on the date of the accident.

1.11. Flight recorders

The aircraft had a Digital Flight Data Recorder (DFDR) and a Cockpit Voice Recorder (CVR), both located in the aft section of the fuselage. They were recovered undamaged from the airplane.

1.11.1. *Digital Flight Data Recorder (DFDR)*

The aircraft was equipped with a HONEYWELL solid-state Digital Flight data Recorder, P/N 980-4700-042 and S/N 08701

The DFDR was read at the Iberia recorder laboratory (STAR) and the information recovered was analyzed at the CIAIAC.

Once the information was confirmed to have been properly recorded, investigators proceeded to study various parameters related to the event.

The data recorded throughout the entire flight were normal until the aircraft commenced the approach phase. As a result, it was decided to focus the analysis on this phase of the flight, the findings of which are presented below.

All of the times are shown in terms of seconds before the initial contact with the runway, which was identified as the instant during which a high vertical acceleration of 5.3 g's was recorded, or in terms of the seconds following that instant.

Geographical coordinates

The complete sequence of the latitude and longitude parameters recorded was taken into consideration in preparing the map of the trajectory taken by the aircraft that is shown in Appendix A.

LOC and GP deviations from the approach path

The localizer was captured normally four and a half minutes prior to arrival at Seville while at a barometric altitude of 4,000 m. From that time on, the LOC and GP were followed constantly until, some sixty seconds before touchdown, the aircraft started to climb above the glide path.

Radioaltitude RA, barometric altitude and glide path

The recorded ground speed (GS) was used to calculate the altitude of the ILS slope during every second of the approach. The dashed line represents the glide, with the aircraft's RA shown alongside it. The distance from the aircraft to the touchdown zone TDZ and the barometric altitude are also shown on the graph for reference. Note how, as in the above graph for ILS deviations, the aircraft deviated above the GP at the –60 second mark.

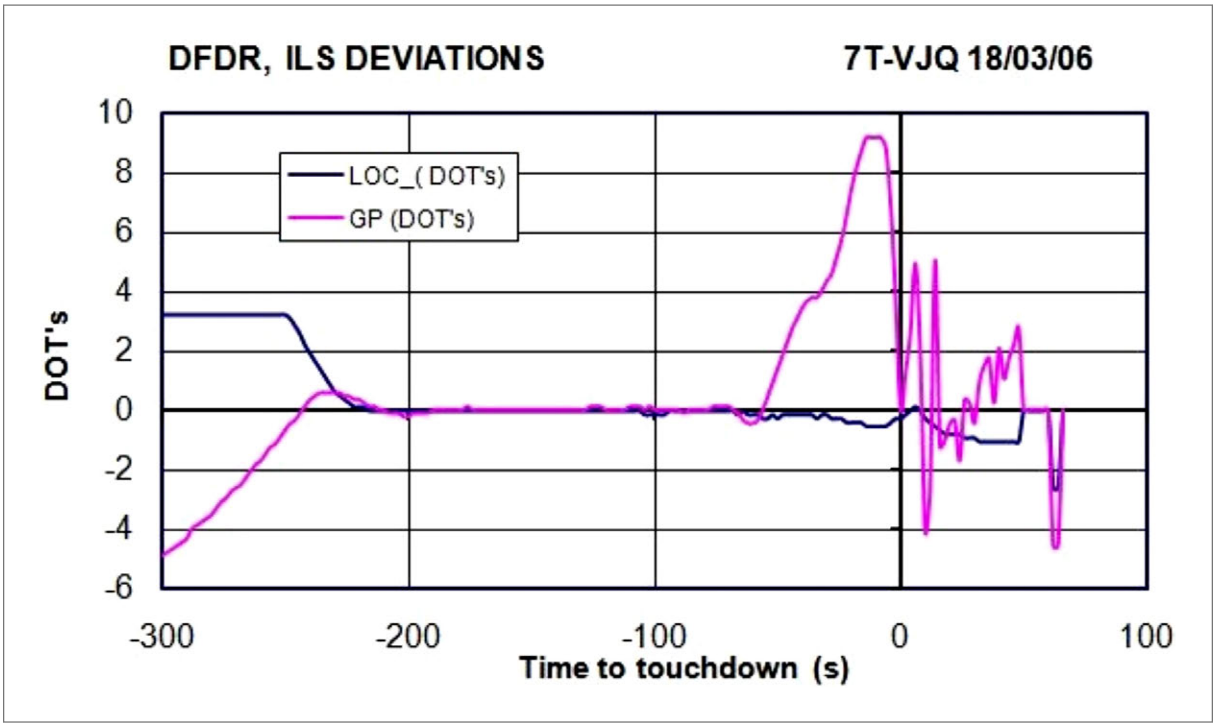


Figure 4. ILS deviations

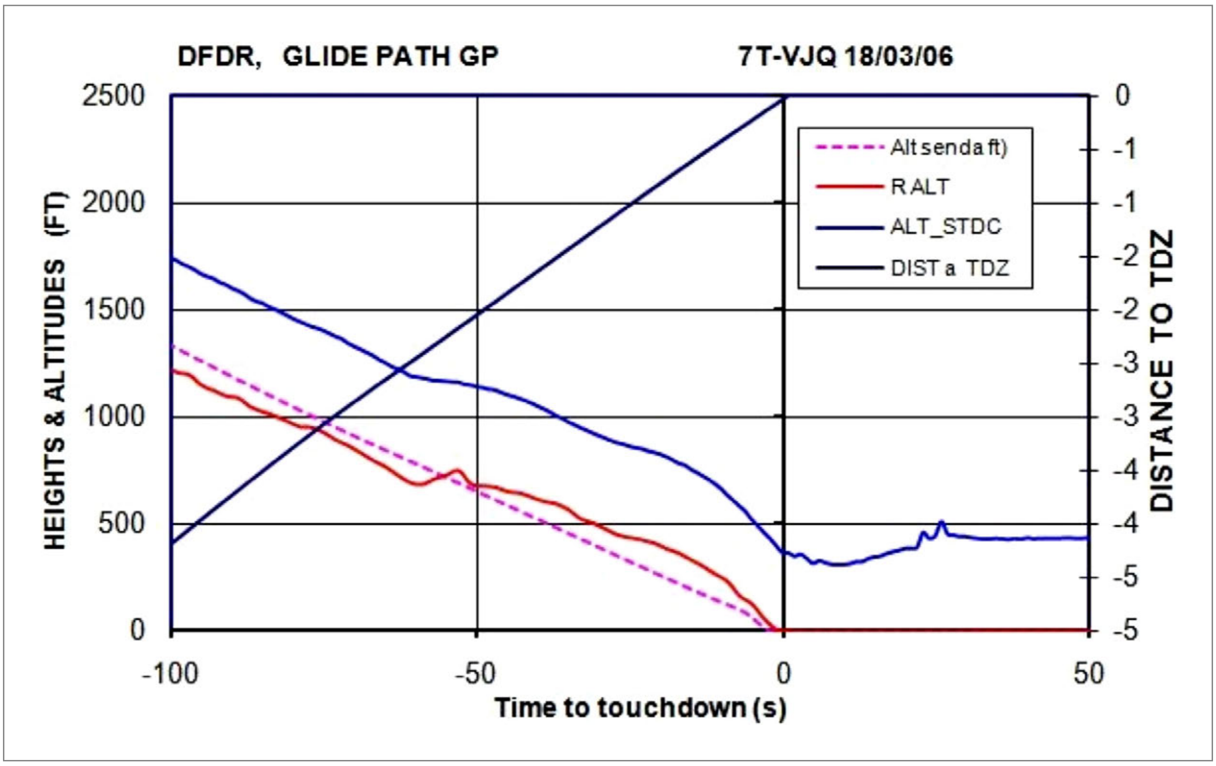


Figure 5. Glide path

GPWS warnings

The following GPWS warnings were recorded on the DFDR:

Time	Warning
–7	SINK RATE
–6	PULL UP
–5	PULL UP
–4	PULL UP
–3	PULL UP
–2	PULL UP
–1	PULL UP
0	SINK RATE
1	SINK RATE

Descent rate

The graph for both the direct RoD readings (from the IVV, Inertial Vertical Velocity) and the calculated RoD (from the change in RA and the barometric altitude) are shown in the graph below.

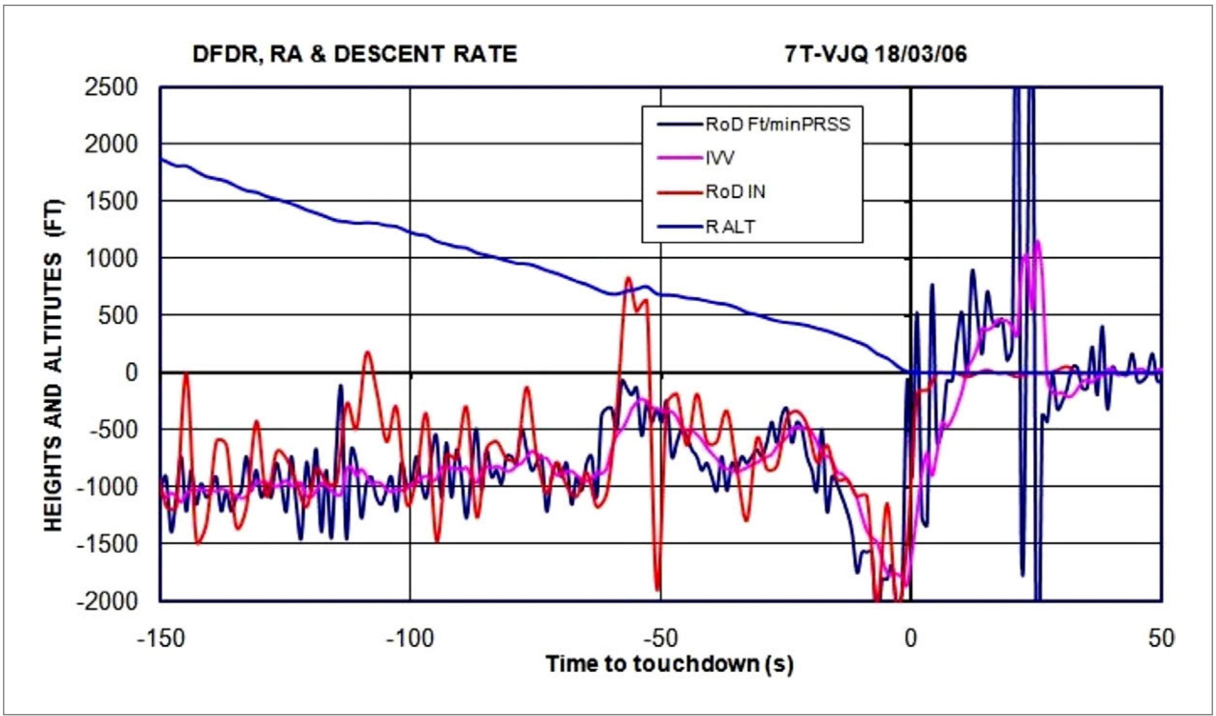


Figure 6. Rate of descent

Note how a descent rate of between 1,500 ft/min and 2,000 ft/min was reached in the ten seconds prior to touchdown.

Changes in pitch, angle of attack and left elevator deflection

The angle of the right elevator is not shown because it is similar to that for the left. A second data set for angle of attack (AOA) values recorded on the DFDR is also not shown for the same reason. In general, small angles are observed throughout. The elevator is capable of moving ± 19 degrees to make for a more pronounced flair. The pitch angle is negative before touchdown and goes to zero at the moment of contact.

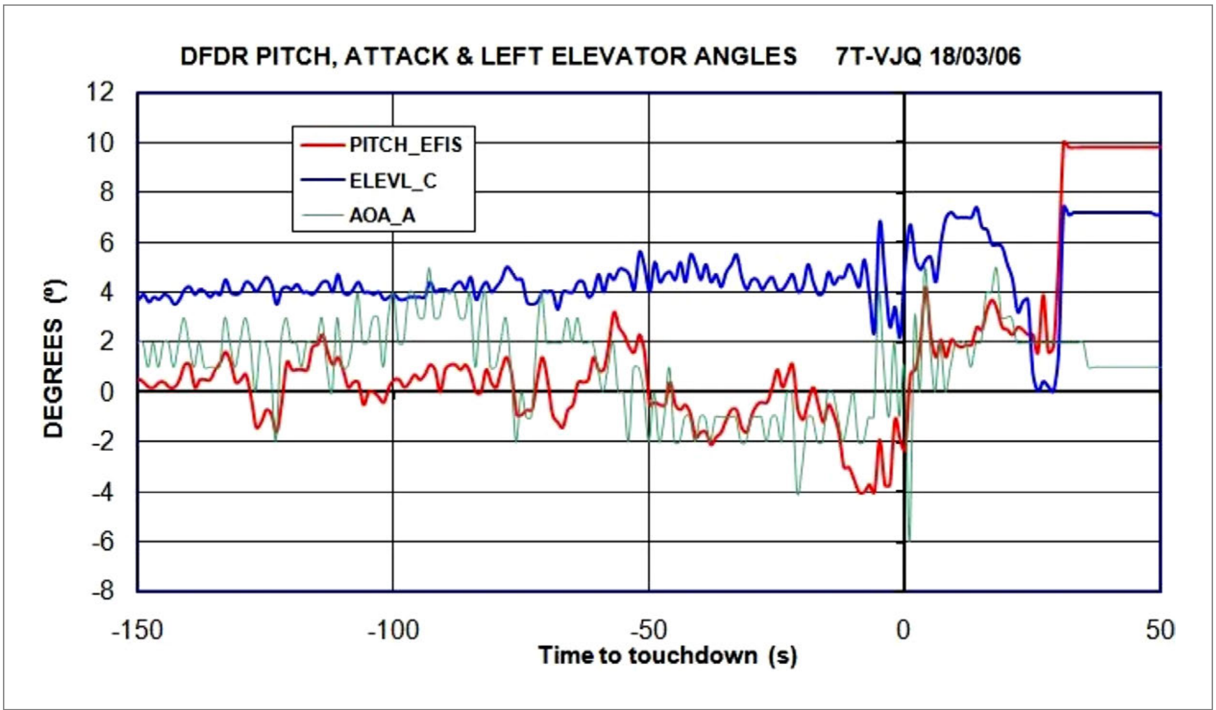


Figure 7. Pitch, attack and left elevator angles

Change in engine parameters

The parameters for the throttle lever position, N1.1 and N1.2 revolutions of the low-pressure spools and fuel flow to both engines are shown below. Note the variation in the throttle positions and in engine power prior to the capture of the ILS. Power was kept relatively stable and low in both engines during the first part of the approach, followed by a spike in thrust sixty seconds before touchdown.

A few seconds after touchdown power increased in both engines in the reverse direction. Non-graphed parameters show the deployment of the reverse thrusters.

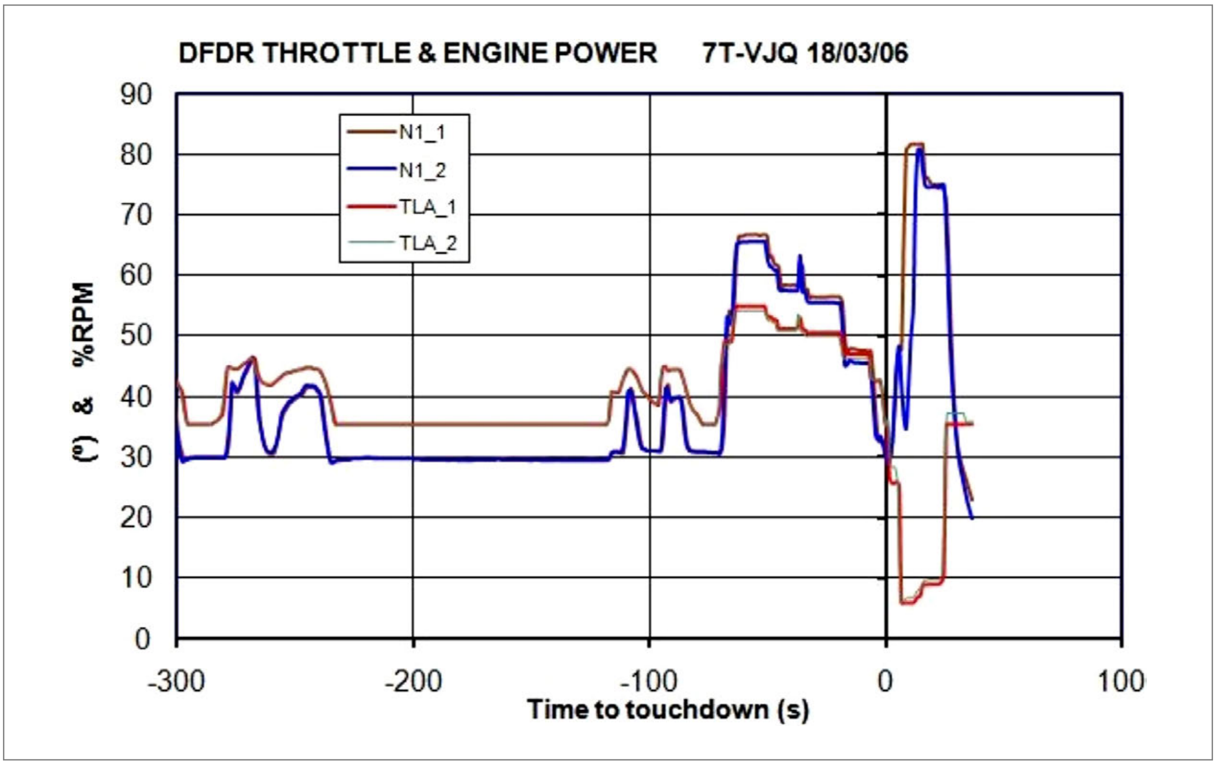


Figure 8. Engine power

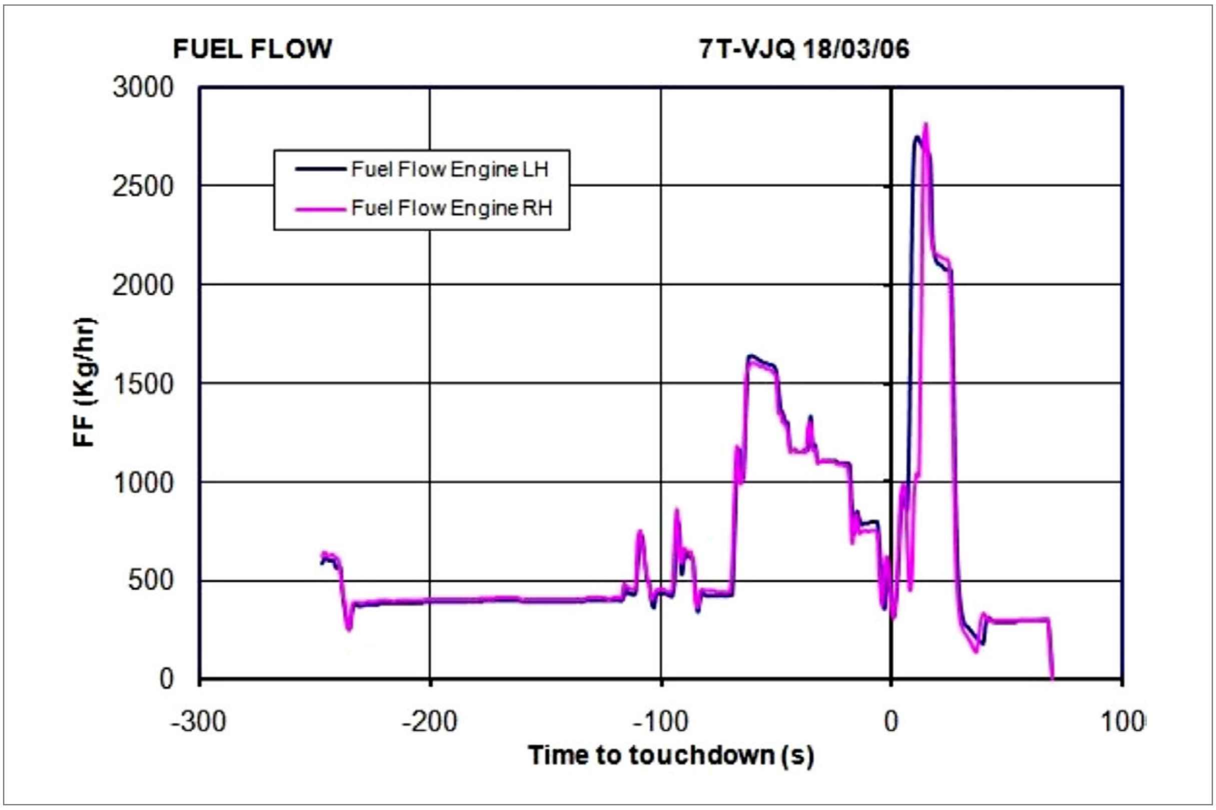


Figure 9. Fuel flow

Change in aircraft's magnetic course

During the final glide, the aircraft's course oscillates around the 273° magnetic heading of the runway. Ten seconds before touchdown the airplane is facing some 6° left of the runway. During the landing roll, the aircraft suddenly turns ten degrees right at one point. The parameter for the commands input to the pedals, not shown, confirms that they were fully depressed in an effort to correct this deviation. The aircraft's final heading was 267°, that is, some 6° left of the runway orientation.

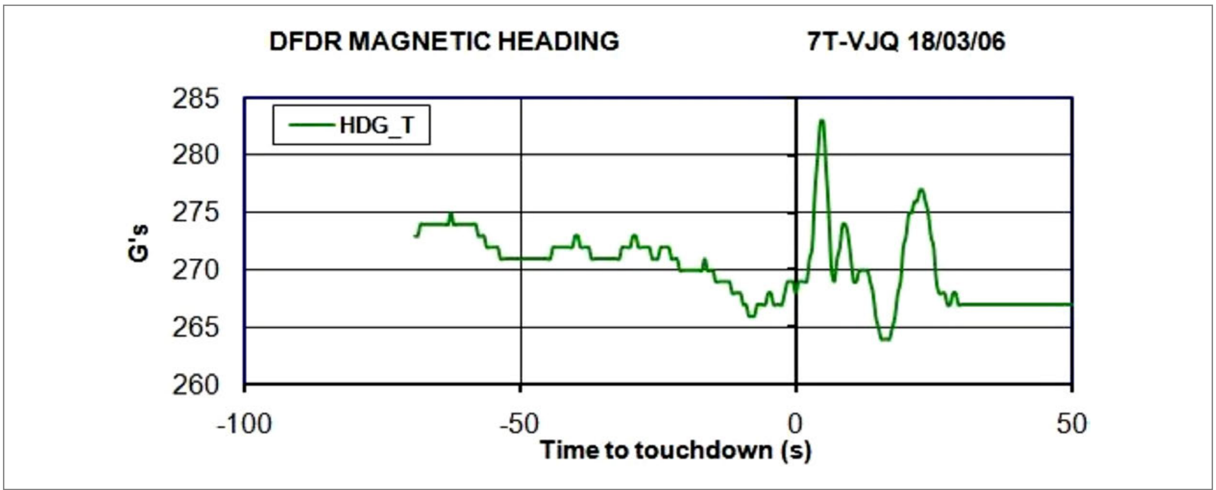


Figure 10. Airplane's magnetic heading

CAS and GROUND SPEED

The speed during the approach was maintained close to 160 kt, dropping to 143 kt at the time of touchdown. The ground speed varied between 140 kt and 150 kt, but was kept at 140 kt during the last ten seconds before touchdown.

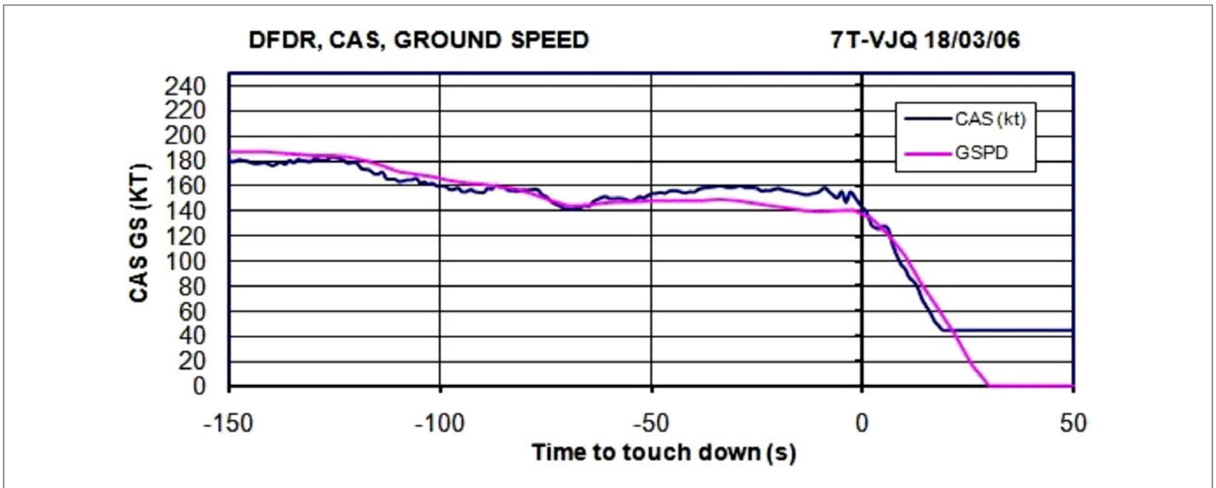


Figure 11. Airplane speeds

Wind speed and direction as felt by the aircraft

Both channels of wind speed as felt by the aircraft in relation to the navigation and inertial references, FMS and IR respectively, are shown below. The winds shifted from

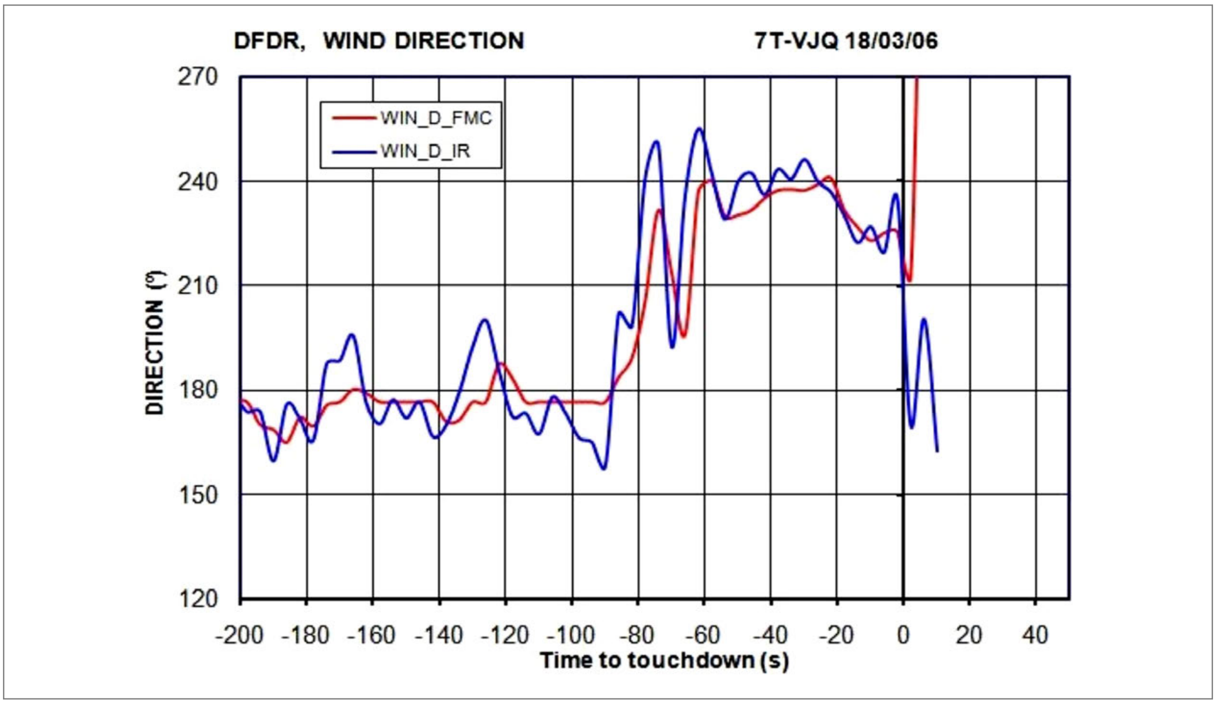


Figure 12. Wind direction

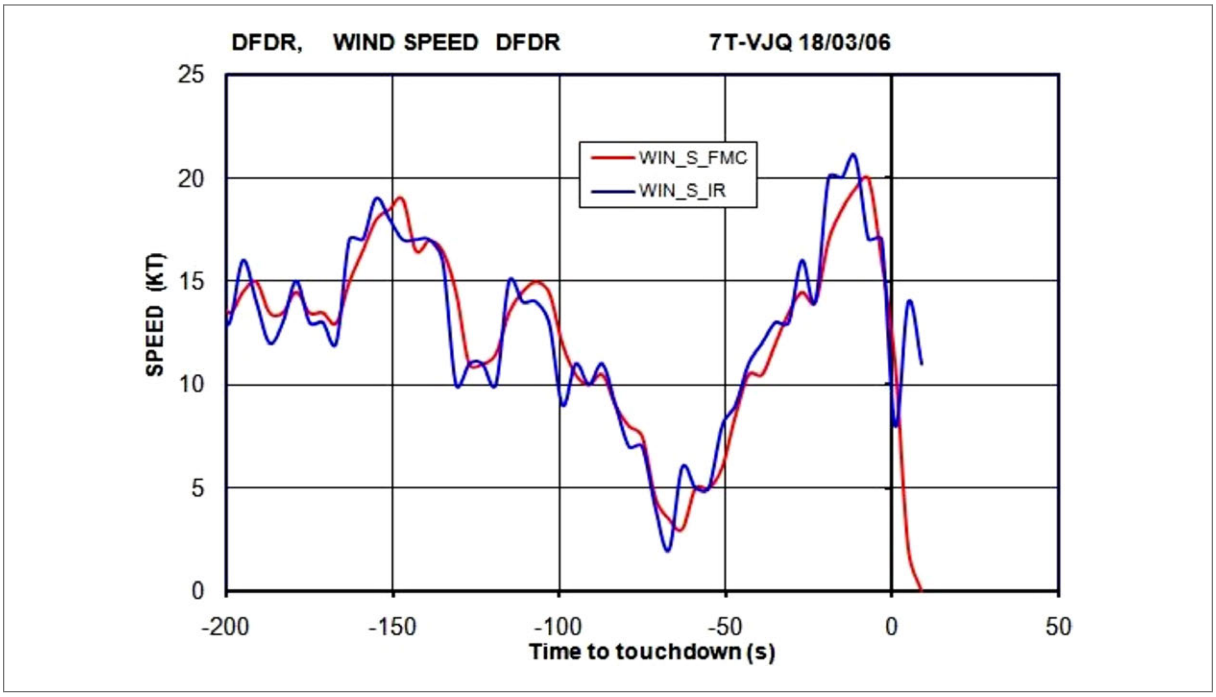


Figure 13. Wind speed

the S to the SE in the final minute of the approach, increasing to as much as 20 kt. Both recorder channels show a very similar trend.

Vertical, lateral and longitudinal accelerations

The vertical acceleration graph shows in-flight values of between 0.8 g's and 1.2 g's.

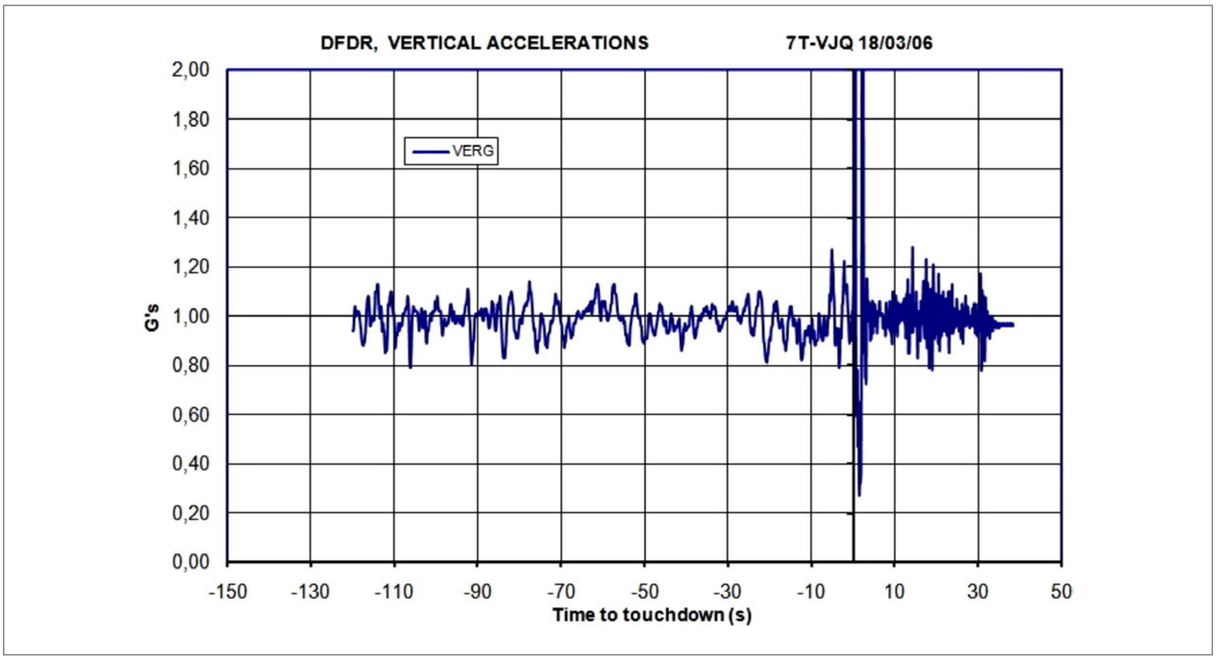


Figure 14. Vertical acceleration during the approach

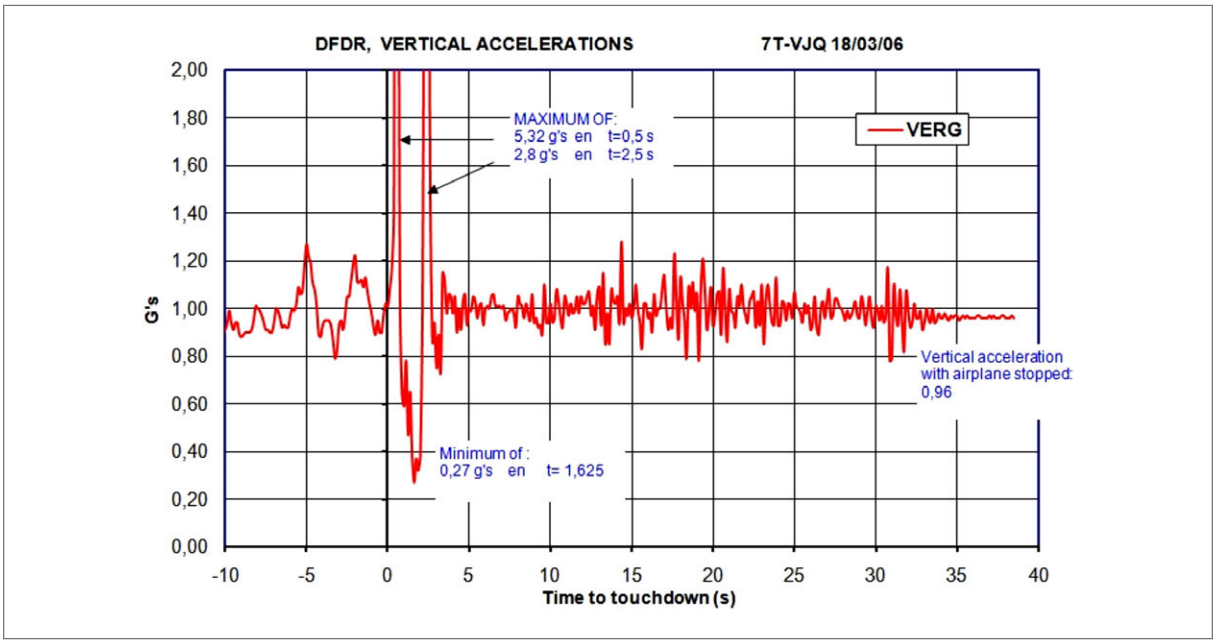


Figure 15. Vertical acceleration during the landing run

At the moment of touchdown, high values are reached, as discussed next in greater detail. The largest in-flight oscillations take place five seconds prior to touchdown. Following contact, the acceleration peaks at 5.32 g's and drops to 0.27 g's before rising again to 2.8 g's at t = 2.5 s.

The lateral acceleration values were only slightly elevated after the touchdown.

Two and a half seconds after touchdown, the longitudinal acceleration reached a momentary value of –0.47 g's, rising again after five seconds to a level of deceleration of –0.3 g's before the airplane reaches a full stop.

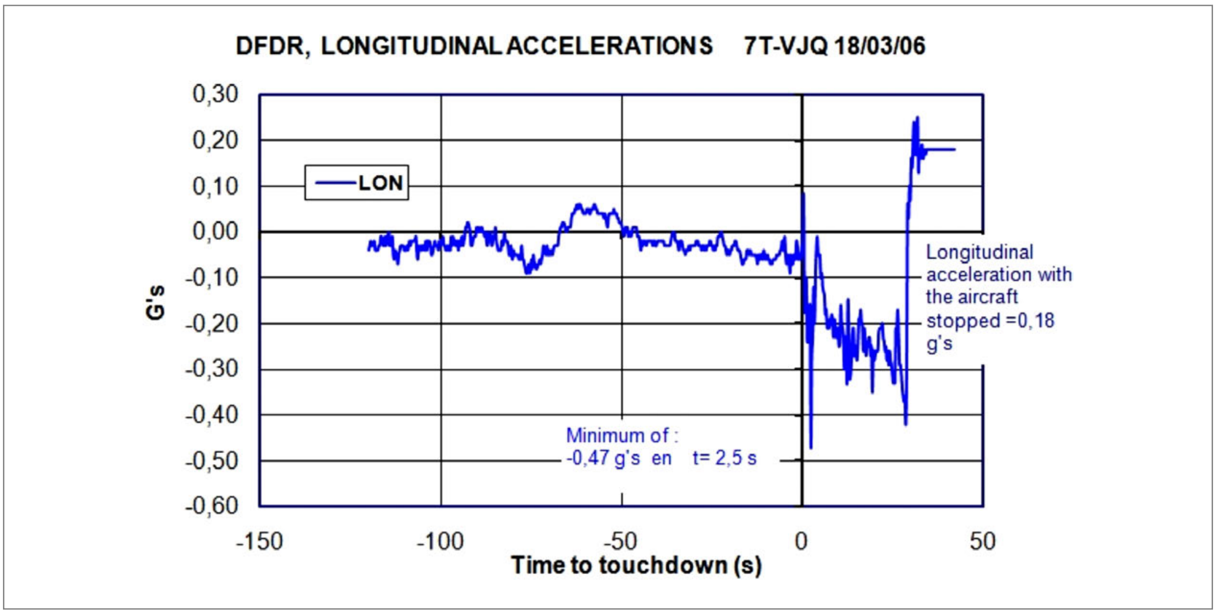


Figure 16. Longitudinal acceleration

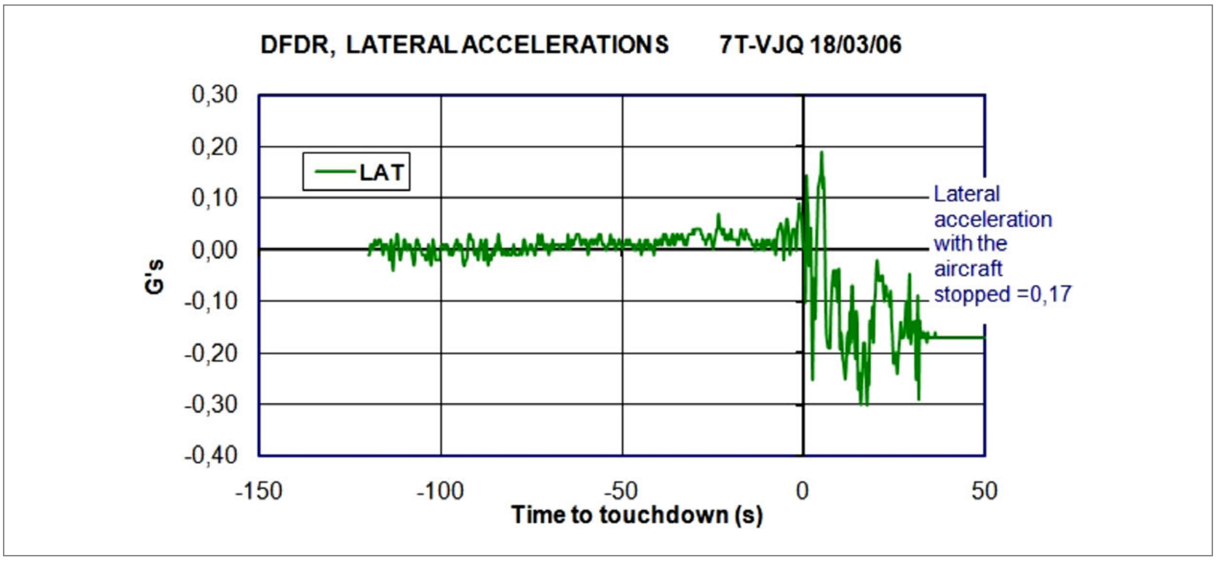


Figure 17. Lateral acceleration

With the aircraft fully stopped, the acceleration values recorded are 0.96 g's vertically, –0.17 g's laterally and 0.18 g's longitudinally.

Information on ground sensors on all three landing gear legs and on ground spoiler panels

The first indication that the airplane contacts the ground occurs when the microswitch in the left leg is activated at time t=0. The DFDR records these parameters every quarter of a second.

A quarter of a second after the left leg records touchdown, simultaneous signals are recorded for the right and nose gear legs.

The nose gear leg becomes airborne again at t = 1½ s and the left leg at t = 1¾ s.

Time	UTC	LDG_LH	LDG_NOSE	LDG_RH
–0.75		—	—	—
–0.5		—	—	—
–0.25		—	—	—
0	9:34:06	GND	—	—
0.25		GND	GND	GND
0.5		GND	GND	GND
0.75		GND	GND	GND
1	9:34:07	GND	GND	GND
1.25		GND	GND	GND
1.5		GND	—	GND
1.75		—	—	GND
2	9:34:08	GND	GND	GND
2.25		GND	GND	GND
2.5		GND	GND	GND
2.75		GND	GND	GND
3	9:34:09	GND	GND	GND
3.25		GND	GND	—
3.5		GND	—	—
3.75		GND	—	—
4	9:34:10	GND	—	—
4.25		GND	—	—
4.5		GND	—	—
4.75	6	GND	—	—

Both immediately make contact again at t = 2 s, after which the left leg remains on the ground. From then on and until the airplane comes to a stop, the microswitch on the nose leg activates sporadically, while the right leg loses its signal permanently at t = 3¹⁄₄ s.

Time	Ground spoiler int	Ground spoiler ext
–1	DOWN	DOWN
0	DOWN	DOWN
1	**UP**	**UP**
2	**UP**	DOWN
3	DOWN	DOWN

The ground spoilers deploy at the moment of touchdown. A second later the outboard ground spoilers retract, followed one second later by the inboard spoilers.

Brake and hydraulic fluid pressure readings

The brake pressure increased as soon as the airplane made contact with the runway. Hydraulic pressure then began to drop, starting with system A.

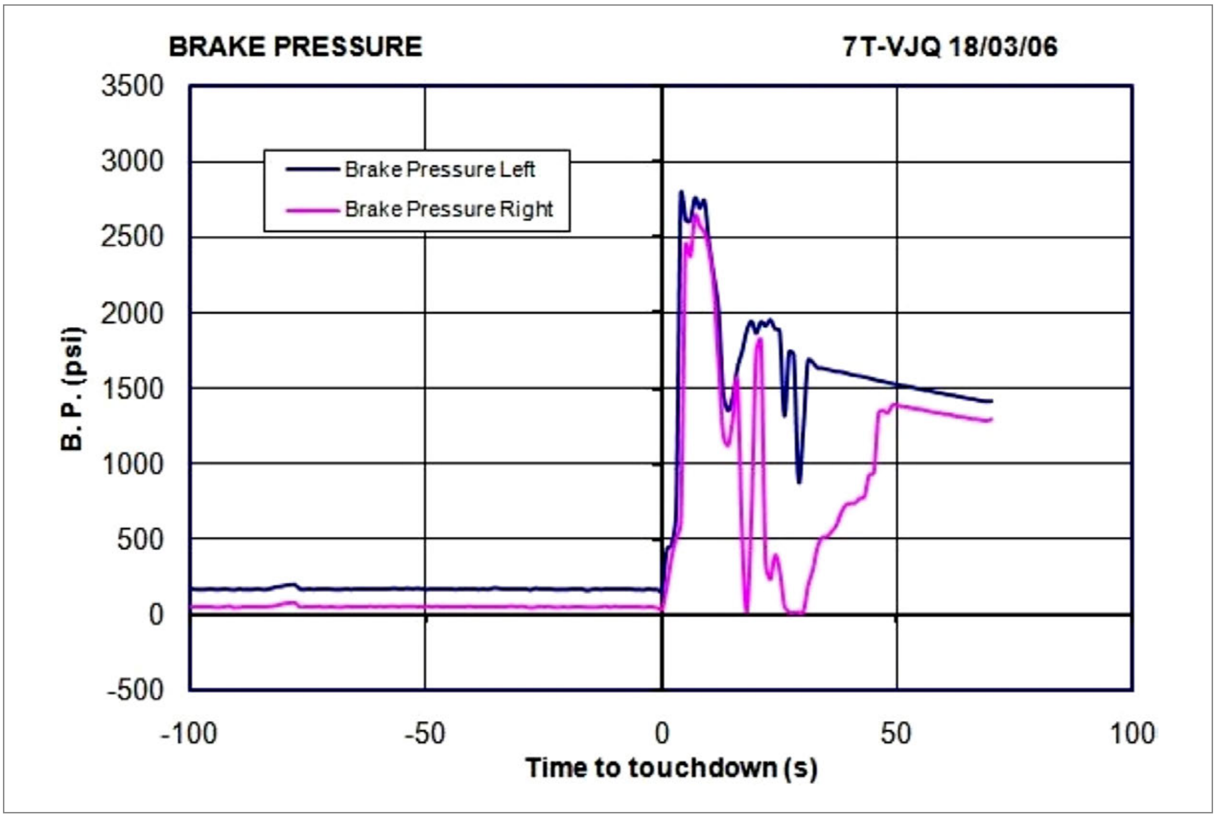


Figure 18. Brake pressure

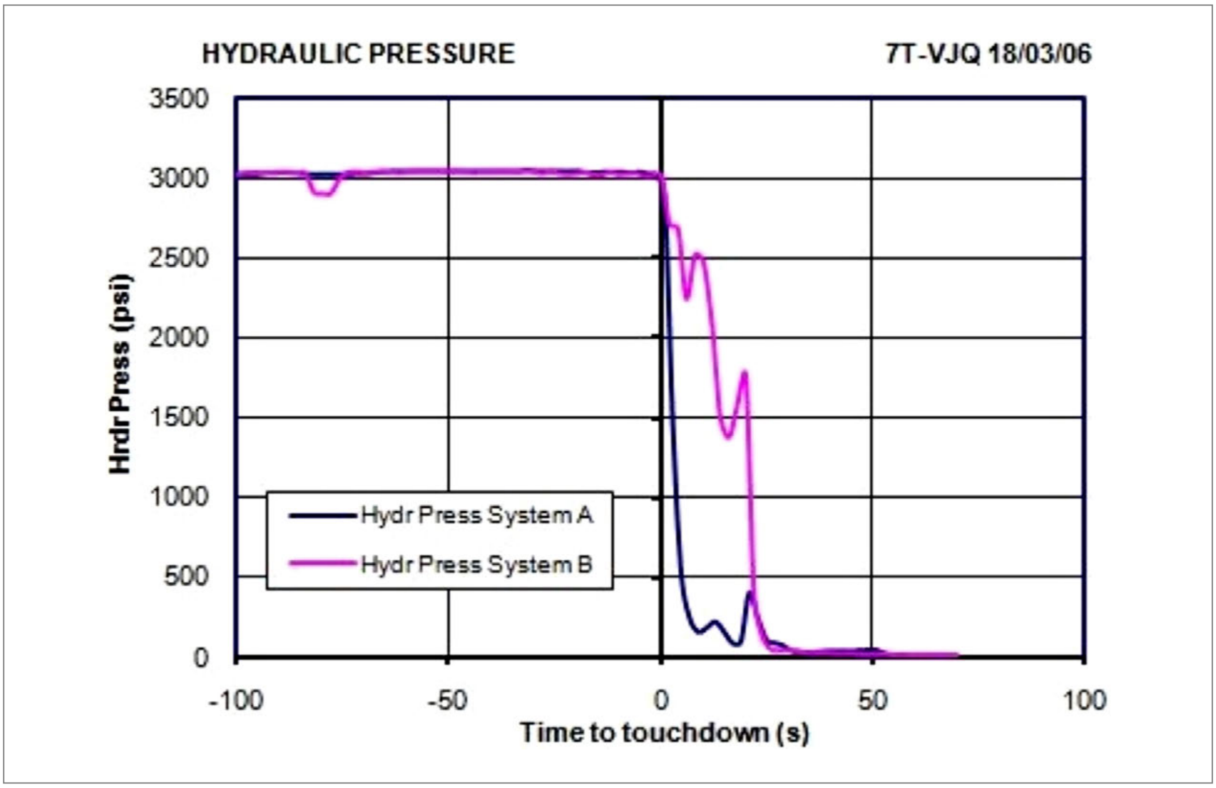


Figure 19. Hydraulic pressure

Windshear parameters

The DFDR system did not record any windshear events during the flight.

Roll angle readings

There is no need to show the variation in this parameter, which was normal until the end of the recording when the airplane's roll angle increased to 9.3°.

1.11.2. *Cockpit Voice Recorder (CVR)*

The aircraft was equipped with a HONEYWELL solid state digital cockpit voice recorder, P/N 980-6022-001 and S/N 05035. Six tracks were recorded on it, four of them lasting 30 minutes - captain's headset, copilot's headset, passenger address system and the cockpit-area microphone - and the other two, corresponding to the cockpit-area microphone and a mixture of the other channels, lasting 120 minutes.

The CVR was read at Iberia's flight safety unit. Good recordings were obtained for all the channels.

The voices recorded spoke in Arabic, French and English, the last being used to communicate with ATC and as part of automated services like the AIS. A transcript of the recordings was made in both French and English at the CIAIAC with help from the aircraft operator.

These recordings were synchronized with the data obtained from the DFDR using the timing marks from the VHF communications.

The CVR transcript reveals that:

- The flight was uneventful until the start of the approach into Seville.
- The crew was aware of the weather situation and of the presence of storms over Seville. It tuned into the Seville ATIS and acknowledged the information relayed by ATC.
- The crew reviewed the approach and go-around procedures. They calculated that the reference speeds for the approach and go-around were 127 kt and 132 kt, respectively.
- The captain realized that the storm, both visually and as seen on the weather radar display, and the airplane would both reach Seville at the same time.
- About two minutes before touchdown and at an altitude of 1,500 ft, they established visual contact with the runway.
- They disengaged the autopilot below 1,000 ft and continued manually. They armed the spoilers.
- The APP controller did not have weather information on his screen.
- The crew voiced concern over the wind during their conversations.
- The wind reported by TWR three minutes before touchdown was 240°/10 kt, and 240°/15 kt fifty-one seconds before touchdown.
- The EGPWS issued the following alerts: 2,500 ft, 1,000 ft, 500 ft, 200 ft, MINIMUMS, SINK RATE and PULL-UP.
- Twenty-four seconds before touchdown, after the 500 ft EGPWS announcement, the Captain requested the copilot's attention by saying, "Don't look there please, stay with me... stay with me OK".
- The sound of the impact upon touching down was recorded through the area microphone.
- Seven seconds after touchdown the CVR recorded the notification given by a pilot waiting to take off of the damage to the 737 that had just landed.
- The order to evacuate was given 34 seconds after the initial contact with the runway.

Appendix D shows an extract of the transcripts.

1.12. Wreckage and impact information

The aircraft made contact with the runway at the start of the aiming point at a high speed and rate of descent. The touchdown resulted in a vertical acceleration value of

5.3 g. The right main gear leg collapsed and partially detached from its support structure. From that point on, the aircraft remained level and followed a nearly linear trajectory on the runway, with the right engine nacelle above the line marking the right edge of the runway. After a run of about 750 m, the right wing started to droop and the right engine nacelle came to rest atop the runway surface as the aircraft stopped along the right side of the runway, resting on its tail and said nacelle following a landing run of approximately 900 m.

Debris from the right main gear leg and from the inboard part of the aircraft's right wing, specifically components from doors, panels and fairings, were found all along the aircraft's trajectory on the runway.

The first signs of debris were found at the start of the aiming point, where a gear panel was found. From that point on, and over a length of some 400 m along the runway, various bits and pieces from spoiler and flaps panels and components from the right main landing gear leg were found on the runway. Some 750 m away, on the right edge of the runway, there were two runway edge lights that had been broken by an impact. Broken glass from one of these lights was found inside the right engine nacelle.

The aircraft stopped at a point along the right edge of the runway past taxiway C-2, some 900 m away from the aiming point zone. The entire airplane was on the paved surface with the exception of a two-meter section of the right wing that was resting on the compacted ground of the runway strip.

After coming to a stop, the airplane was resting on its right engine, the tires of the left main landing gear and the tail, or aft fuselage, section. Its longitudinal axis was at an 8.46° angle with respect to the runway centerline and at a 9.6° angle with respect to the runway's horizontal plane. The fuselage retained its integrity and the nose wheels were about 1.5 m above the ground. Due to the abnormal attitude in which the airplane stopped, the front doors were situated at a higher altitude than normal.

1.13. Medical and pathological information

An unspecified number of aircraft occupants were treated by medical services for minor injuries and bruises.

1.14. Fire

There was no fire.

1.15. Survival aspects

The exterior of the aircraft suffered localized damage to the right main landing gear leg and to the right wing near the area where it attaches to the fuselage.

As for the inside of the airplane, three overhead panels on the right side of rows 1, 5 and 12 detached, along with their respective monitors. The passenger seated in the rightmost seat of row 1 was struck in the head by one of these panels.

Once the aircraft came to a stop, the crew entered the corresponding emergency procedure and ordered its evacuation in the midst of a heavy downpour. The forward and aft doors on both sides were used for the evacuation, along with the associated ramps. The emergency exits above the wings were not used. Since the front doors were at a greater height above the ground than usual, their evacuation slides were steeper than normal, though this did not keep them from resting firmly on the ground so they could be used for the evacuation.

The control tower was informed of the damage to the landing gear of DAH2652 by the crew of another aircraft that was at the runway 27 hold point. The on-duty controller also saw the aircraft tilting to the right with its right engine sparking. As a result, the fire alarm was activated in the control tower before the airplane came to a stop, with emergency personnel reaching the aircraft practically as the evacuation was commencing. This resulted in the passengers being attended to as soon as they exited the aircraft.

1.16. Tests and research

1.16.1. *Inspection of aircraft wreckage*

In an effort to repair the aircraft so as to place it back in service, personnel from Boeing conducted an inspection of the aircraft and issued a detailed report of their damage assessment.

The following is a general overview of the main damage found:

- Collapse of the right main landing gear leg, with partial separation from the airplane structure. Significant damage to hydraulic and electrical lines.
- Significant damage to main landing gear beam.
- Broken trunnion bearing housing in the aft spar.
- Nose wheel axle bent and the tires on those wheels scuffed.
- No apparent damage to the left main landing gear leg.
- Various sections of fuselage skin, stringers and shear ties crumpled and damaged in sections 41 and 46 of fuselage structure.
- Inboard flap assembly on right side destroyed, including rails, fairings, gears and fastening components.
- The right engine had ingested foreign object debris (FOD) and several fan blades had been dented. The cowls and reversers had also been damaged to the point that they had to be replaced.
- A cowl on the left engine was bent.
- Inside the airplane three overhead panels and their associated video monitors fell to the floor and an interior wall panel was cracked.

1.16.2. *Study of structural damage*

The NTSB (National Transportation Safety Board, the agency responsible for investigating civil aviation accidents and incidents in the United States) was sent some components from the support structure for the right main landing gear leg so that it could conduct a detailed study in its laboratories of the way in which the breaks and deformations present could have occurred.

The following components were sent:

- Forward trunnion bearing housing and its four cap fuses.
- Three fractured pieces of the pin that fastens the landing gear beam to the aft wing spar.
- The four attachment pins for the LGB stabilizing stays that are designed to be fusible and which did not break.
- The link assembly that joins the side strut to the fuselage, with its broken lug.

The results of the study conducted show that:

- The fusible pin that attaches the LGB to the aft spar failed due to a shear overload in the vertical direction. The hardness of the material was verified to satisfy the design specifications.
- The forward trunnion support was bent and there was a break in the outer race bearing consistent with a relative shift aft of the bearing's inner race.
- The side strut link was bent and the lower attachment lug was broken as a result of having bent backwards. The appearance of the fracture surfaces was consistent with an overload condition. The hardness of the material, checked during the analysis, was within specifications.

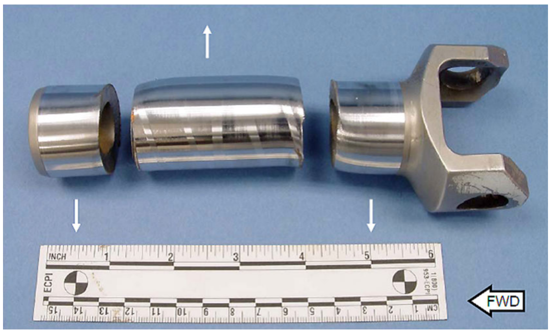


Figure 20. Joint pin

1.17. Organizational and management information

Not applicable.

1.18. Additional information

1.18.1. *Crew statements*

Both aircraft pilots were interviewed on the day of the accident. The more relevant aspects of their statements are presented below.

Captain

It was his first time flying to Seville. He had flown into Madrid and Alicante on numerous occasions before, but never Seville.

That morning he had gone to Oran Airport at 09:00, since the flight was scheduled to depart at 09:30. He reviewed the weather information (METAR, SPECI, TAF) and the NOTAMs, which he had also checked the night before. One detail he remembered from the TAFs is that the forecast called for visibility in excess of 10 km and scattered clouds.

The cruising altitude for the flight was FL310. They listened to the Alicante and Malaga ATIS in case they had to deviate. Everything was normal. They held the pre-descent briefing. He was the pilot flying.

When they were at 4,000 ft, the ATIS reported a visibility of 3000 meters and rain over Seville. They were cleared for the approach, configured the airplane and, when on long final, the tower reported a wind of 240°/15 kt. They went around a vertical development cloud, did not encounter windshear and saw the runway at 1,500 ft.

During the flair they encountered very heavy precipitation that made it difficult to identify the runway centerline. He decided not to go around because the situation at the far end of the runway, made darker by the storm, was worse, which would complicate the go-around. The airplane went right and they made a very hard landing. They bounced and thought a tire might have blown out, but not that a landing gear leg had failed. In his opinion, it was all due to the heavy rain they encountered at the last moment.

Copilot

It was also his first time flying into Seville and that morning he had arrived at the airport in Oran at 08:30.

The airplane had arrived from Tindouf with another crew, so it was already prepared for the flight.

The flight, during which he was the pilot not flying, was uneventful.

With respect to the final phases of the flight, he remembered that the last ATIS reported a visibility of 3,500 m and that they were cleared for the approach.

On short final he told the Captain he was coming in a little to the right, which the Captain acknowledged and corrected. The descent rate was a little high, 1,000 ft/min as he recalls, and the GPWS sounded the “Sink Rate” warning. The speed on landing was about 10 kt higher than reference speed (Vref + 10 kt). He made the standard call-outs.

Before touching down they encountered heavy rain. The Captain lifted the nose and they made a very hard landing. The airplane bounced and touched down again to the right of the runway centerline. It did not feel as if the landing gear had failed, only that it had been a very hard landing.

They did not encounter windshear and he felt they were too close to the ground to do a go-around when they ran into the heavy rain conditions. Besides, he did not expect any problems with the landing because the runway was so long.

1.18.2. *Statement from the on-duty TWR controller*

He went on duty at 09:50. He remembers that at that time the wind was from 180° and that when the accident aircraft landed it was from 240° at 10 to 15 kt.

While the aircraft was on short final, another one was waiting. The visibility in the direction of the 27 threshold was hazy. There was a wall of water and also lightning. The RVR stayed above 2000 m at all times, both before and after the downpour.

The airplane came in cocked to the right. He saw a flash of light in the engine, as if it had caught on fire, though he then noticed that it had not.

Another controller on duty pressed the alarm button to notify emergency services before the airplane came to a stop.

The pilot had requested another wind reading 4 NM prior to landing. The first wind report had been given when the landing was authorized (which had been a short time earlier, 2-3 minutes prior to landing).

At 09:50 the intensity of the runway lights was set to 4. Before the airplane arrived, it was turned up to the maximum (5).

His personal opinion is that the approach was correct, as evidenced by what he saw on the Raster equipment installed in the control tower.

Finally, he reported that the last airplane to depart before the landing was cleared to climb on runway heading at the pilot's suggestion to avoid flying into the storm.

1.18.3. *Criteria for a stabilized approach*

In the training manual for B-737 type aircraft (FCTM - Flight Crew Training Manual), Boeing recommends that all approaches be stabilized prior to reaching 1,000 ft AGL in instrument meteorological conditions (IMC) and 500 ft AGL in visual meteorological conditions (VMC).

It likewise specifies that an approach is considered stabilized when it meets all of the following criteria:

- the airplane is on the correct flight path
- only small changes in heading and pitch are required to maintain the correct flight path
- the airplane speed is not more than VREF + 20 kt indicated airspeed and not less than VREF
- the airplane is in the correct landing configuration
- sink rate is no greater than 1,000 fpm; if an approach requires a sink rate greater than 1,000 fpm, a special briefing should be conducted
- thrust setting is appropriate for the airplane configuration
- all briefings and checklists have been conducted.

Specific types of approaches are stabilized if they also fulfill the following:

- ILS and GLS approaches should be flown within one dot of the glide slope and localizer, or within the expanded localizer scale
- during a circling approach, wings should be level on final when the airplane reaches 300 feet AFE.

Unique approach procedures or abnormal conditions requiring a deviation from the above elements of a stabilized approach require a special briefing.

Note: An approach that becomes unstabilized below 1,000 feet AFE in IMC or below 500 feet AFE in VMC requires an immediate go-around.

These conditions should be maintained throughout the rest of the approach for it to be considered a stabilized approach. If the above criteria cannot be established and maintained at and below 500 feet AFE, initiate a go-around.

At 100 feet HAT for all visual approaches, the airplane should be positioned so the flight deck is within, and tracking to remain within, the lateral confines of the runway edges extended.

As the airplane crosses the runway threshold it should be:

- stabilized on target airspeed to within + 10 knots until arresting descent rate at flare
- on a stabilized flight path using normal maneuvering
- positioned to make a normal landing in the touchdown zone (the first 3,000 feet or first third of the runway, whichever is less).

Initiate a go-around if the above criteria cannot be maintained.

2. ANALYSIS

2.1. Dispatch and conduct of the flight

The flight was dispatched normally. The crew had arrived at the airport of Oran early enough to analyze the situation, the flight plan and the load sheet. The airplane was expected to be filled to capacity, meaning the operating weight, especially on landing, would be high. They knew beforehand of the worsening weather situation at the destination.

They took off from Oran at 09:36 and a little less than an hour later they were making their initial approach to Seville. They had listened to the 10:00 and 10:15 ATIS reports and knew to expect stormy and rainy weather upon arrival. In their conversations they expressed their concern with the wind. Visibility was not bad, with RVR extending out to 3,000 m at times, and always in excess of 2,000 m. Although there were a few clouds at 800 ft, the ceiling was at about 2,000 ft.

ATC cleared them to descend to 4,000 ft first and then to proceed directly to the initial approach fix at ROTEX at the pilot's discretion so that they could go around the storms. There was some confusion between the crew regarding whether they were cleared to descend below 4,000 ft (the ILS procedures into Seville RWY-27 specify an altitude of 2,000 ft). Since they were cleared to proceed "at their discretion and in accordance with their procedures", they decided to capture the ILS slope at 4,000 ft, which would extend the time on the glideslope and enable them to fine tune the maneuver and better prepare the arrival.

While descending on the glideslope, a departing aircraft requested permission to deviate from the departure course to the left so as to avoid the storm. The loud noise of the rain against the windshield was picked up on the CVR. The crew saw on the weather radar how the approaching storm's arrival at the airport would coincide with theirs.

Once in contact with the TWR, some three minutes before touchdown at an altitude of 3,000 ft, they received wind information from the controller, who reported it at 240° and 10 kt. The runway might have been flooded as a result of the 31 mm of rain dumped by the heavy downpour.

The airplane did not deviate from the localizer track at any point during the approach, as shown in the trajectory given in Appendix A.

The crew had completed the procedurally required checklists and had configured the airplane with the landing gear down and flaps 30°. They calculated a reference speed of 127 kt. They also reviewed the procedures for a go-around and for taxiing in low visibility.

With the runway in sight at 1,500 ft AGL, they continued with the descent until the GPWS 1,000 ft notification. They then disengaged the autopilot and requested the latest wind information, which was then 240° and at 15 kt. At that time, the wind, this had been from the left, shifted to a headwind as the aircraft drifted slightly below the glideslope. The pilot flying increased the throttle, with the N1 on both engines going from between 30% to 40% to values of 65%. The CAS was approaching 160 kt. The aircraft stopped descending temporarily and climbed above the glideslope. The GPWS did not notify passing through 500 ft since it only does so if flying below the glideslope. The airplane started deviating gradually from the glideslope such that as it reached minimums, it was at twice the theoretical altitude. The pilot reduced thrust and maintained the pitch and high speed with respect to Vref with only slight variations. The actual glideslope was about 6°.

An aircraft descending at a GS of 160 kt on a 6° glideslope has a descent rate of 1,700 ft/min. The GPWS worked properly. At that rate of descent, as soon as the aircraft dropped below minimums, it sounded the SINK RATE and PULL UP warnings.

The tension in the cockpit from the storm, wind and rain made the pilots deviate from standard procedures. At one moment, already below 500 ft, the Captain is heard on the CVR telling the copilot "don't look there... stay with me... stay with me". The reason for the admonition is unclear, but it does seem to indicate a certain tension and lack of coordination. The approach was in fact unstabilized, with the glideslope bar completely outside the Flight Director, a descent rate that was double the normal rate and a high speed in excess of the Vref + 20 that is normally used. At any rate, the possibility of windshear could have led them to choose a higher speed, which the long length of runway available could certainly accommodate. The engine rpm's were very high and variable.

There was no clear flare before the landing. The aircraft, which seconds prior to landing had even attained negative pitch values, only just managed to level out before making initial contact. The elevator angles used (only 4°) were far below the 19° available. This surface could have been used to its full extent to adopt a pitch angle of up to 8° well before the landing without running the risk of a tail strike.

The visibility remained relatively high, but the lack of clarity could have prevented the pilots from properly recognizing the condition of the aircraft. In the last part of the approach, almost over the runway and on a 6° glideslope, the aircraft stayed on a direct slope toward the touchdown zone, where it made initial contact. Had the pilot opted to follow a normal 3° glideslope, the glide would have been extended by about 1,000 m, but the descent rate would have been lower and there would still be about 2,000 m of runway available for the landing run.

Once on the ground, the airplane was steered by fully depressing the pedals and slowed with reverse thrusters. The airplane remained on the runway.

2.2. Weather considerations

The crew knew from the start of the flight that they could encounter storms upon arriving at Seville Airport. Before starting the approach they confirmed that there was in fact a storm in the vicinity of the airport, as they were able to see for themselves on the weather radar. Finally, they were able to see it physically through the cockpit windshield.

In this case, the probability of storms existed for the region as a whole. On a local scale, systems are available to detect and warn of lightning for activities such as aircraft refueling.

The data recorded on the anemometers situated at the runway thresholds reveals that the disturbance that passed through Seville Airport reached the runway 09 threshold first before passing over the runway 27 threshold a few minutes later.

It took the entire disturbance, estimated to measure between 15 and 20 km, over an hour to pass over Seville. The aircraft encountered part of the area occupied by the disturbance while on arrival, perhaps flying ahead of the storm. As shown by the wind data recorded by the DFDR (Figure 10), the wind felt by the aircraft changed suddenly eighty seconds before touchdown, shifting from 170° at 10 kt to westerly, 230°, with growing intensity, from 5 to 20 kt, during the approach.

On a related topic, the CAS and GS graphs reveal appreciable windshear just before touchdown, as the TAS oscillated between ± 6 kt. The wind speed readings recorded on the DFDR also show a drop in speed, going to zero before touchdown, whereas it had been as high as 20 kt a few dozen seconds earlier when the aircraft was still halfway through the approach. This indicates that the downdrafts, turbulence and windshear associated with the heavy rainfall could have destabilized the approach, but not excessively, as confirmed by the fact that the GPWS did not issue a WINDSHEAR warning.

As a result, the phenomena associated with the storm are believed to have affected the stability of the approach, but do no justify the crew's decision not to go around upon noticing that it was not stabilized.

2.3. Probable sequence of events

After a final approach that was unstabilized by a variable head wind, the airplane landed hard while at a slight downward pitch angle of –2.3°. Both the main and nose gear wheels touched the ground simultaneously, with vertical acceleration reaching values of 5.3 g's. The nose wheel axle bent during the initial contact.

The air-ground sensor on the left main landing gear leg (MLG-LH) issued a ground signal a quarter of a second before the other two legs, a signal that remained until the end, except for the DFDR reading associated with t = 1.5 s. The ground signal from the right main landing gear leg (MLG-RH) lasted for three seconds after the touchdown. The ground signal from the nose leg reverted to air mode at the 1.5 and 1.75 second marks after touchdown. It then alternated between air and ground mode from t = 3.5 s until the aircraft finished its landing roll.

After the initial contact with the runway, the airplane bounced, almost achieving zero gravity for an instant with a vertical acceleration value of 0.27 g. The ground spoilers deployed from t = 1 to t = 3 s after touchdown. During that time brake pressure was available to the two main gear legs. At t = 2.5 s, a new peak in vertical acceleration value of 2.8 g was reached, coinciding with a peak of –0.47 g in longitudinal acceleration.

The ground signal in the microswitches in the RH-MLG and the NLG is believed to have been triggered when the airplane first made contact with all three legs as all four main wheels started to spin. This spin-up signal from the main wheels, along with the armed status of the ground spoilers, is what allowed the spoilers to deploy immediately. The airplane, which bounced, lost its lift without the right wheel losing contact with the ground and fell again. It was in this second contact with the runway that high vertical loads from the loss of lift and high horizontal loads generated by the braking action coincided in the right leg. The pilot was fully applying brakes with the antiskid activated, as is appropriate when landing on a wet runway. Under these conditions, the braking action would have been strong.

The reaction of the aft leg support to the vertical load, in conjunction with the reaction to the moment produced by the tire friction, caused the landing gear beam (LGB) support structure to collapse. At t = 3 s after touchdown the right leg detached partially, breaking the air-ground sensor, which from that moment on gave an "air" indication. From then on the braking capacity was lost until it was decided to engage full reverse thrusters.

It is also possible that the extremely hard contact made by the nose gear not only bent the nose wheel axis, but that it might have affected the operation of its air-ground sensor, resulting in erratic indications.

2.4. Fracture mechanism of the MLG-RH support structure

Since the investigation did not reveal any material defects in any of the failed components, nor any deviations in their mechanical characteristics, it is assumed that the fractures occurred due to overloads at the moments of impact when landing and which resulted in high overall acceleration values in the aircraft.

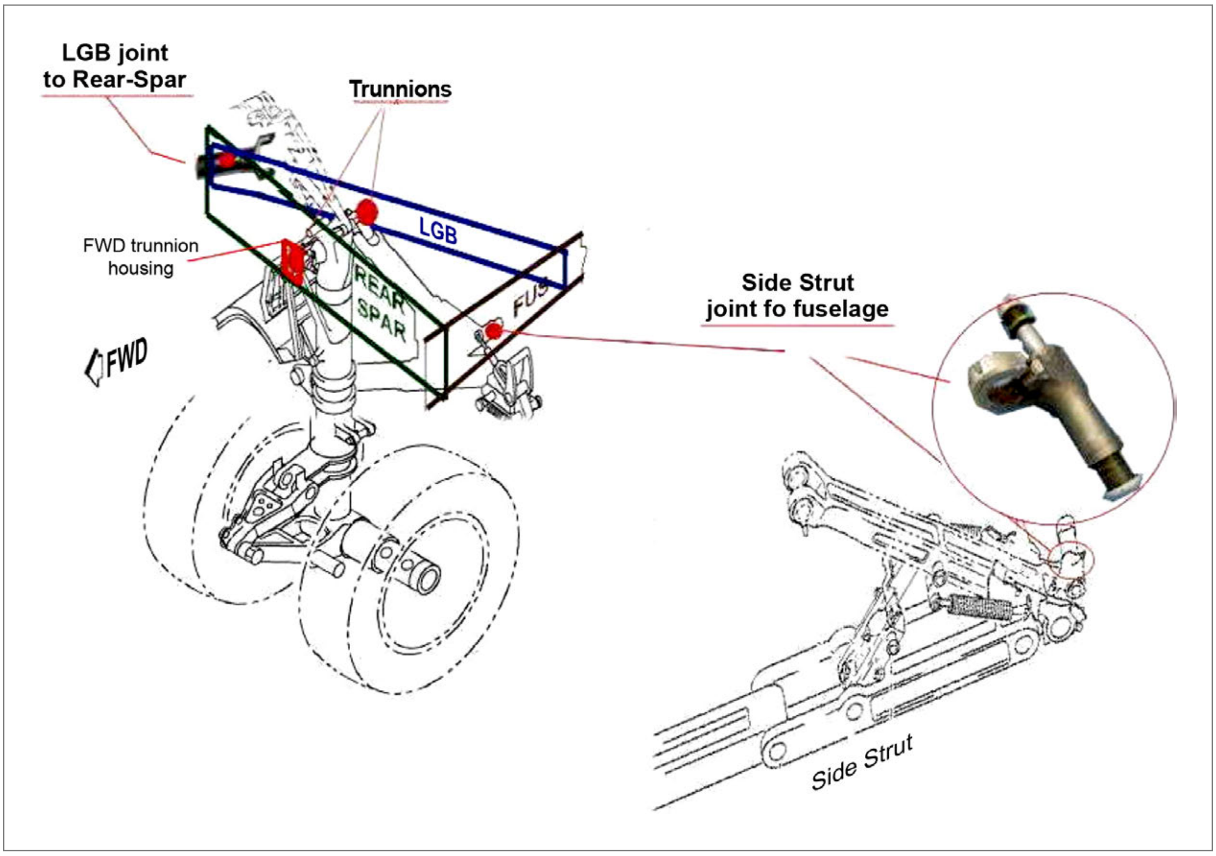


Figure 21. Main structural failures

Vertical grounds loads transmitted through the right landing gear leg to the LGB caused the failure of the fusible link that attached the LGB to the aft spar, as intended by design. When the aft support gave way, the leg moved backwards, causing the forward trunnion to break from its housing. The aft and lateral forces exerted on the wheel loaded the side strut until it failed. At that point the entire leg was attached at a single point, the aft trunnion, and was dragged by the aircraft for the remainder of the landing run.

3. CONCLUSION

3.1. Findings

- The crew was qualified for the flight.
- The aircraft had a valid airworthiness certificate.
- The technical dispatch of the flight in Oran proceeded normally.
- The aircraft, with its 101 passengers and six crewmembers, was flying at close to the maximum landing weight.
- Storms were forecast for the destination airport in Seville.
- The crew was aware of this risk and remained informed of the changing weather situation at all times.
- Although the control tower did not specifically report the stormy conditions with heavy rains and lightning, the crew could see the storm cells and realized they would arrive in Seville in the middle of a storm.
- The ILS glideslope was captured fairly early, while the aircraft was still at an altitude of approximately 4,000 ft.
- Despite the storm and the rain, the crew saw the runway while they were descending through 1,500 ft.
- The reference speed was 127 kt and the aircraft was descending at approximately 157 kt.
- Once lined up on the ILS glideslope the crew had trouble maintaining the proper altitude within the slope. The shifting winds forced the crew to adjust the throttle starting at 700 ft.
- With excess thrust and speed, the aircraft deviated vertically upward above the glideslope, which placed it in a slope with a 6° gradient as they crossed through the decision height with the runway in sight.
- While facing the runway and heading for the aiming point zone, the aircraft's descent speed rose to very high levels for the existing flight speed and glideslope conditions.
- The last wind reported by the control tower was 240° and 15 kt.
- There were no GPWS WINDSHEAR warnings, meaning that there were probably no sudden variations in wind.
- The SINK RATE and PULL UP warnings did sound but the Captain decided to proceed with the landing. The copilot did not notice the deviations that were occurring with regard to the glideslope, the reference speed and the high descent rate.
- The airplane hit the runway hard, breaking the right main landing gear leg, which collapsed and pivoted backward, partially detaching from the airplane.
- The crew managed to control the airplane and bring it to a stop by using full reverse thrust.
- The airplane was emergency evacuated in the middle of the runway in the midst of the storm.
- There was no fire or any serious injuries to the passengers or crew.
- The damage to the airplane was reparable, though the effects from the high load levels exerted were apparent.

- The main failures in the gear leg affected a joint designed to be a weak or fusible link, and another component that joined the side strut on the landing gear to the fuselage.

3.2. Causes

The accident was caused by a very hard landing of the aircraft, during which the right main landing gear was broken, as a consequence of a non stabilized approach.

The aircraft became unstabilized during the approach, which was conducted under stormy weather conditions with heavy rains and lightning, and the crew did not adhere to the applicable standard procedures.

4. SAFETY RECOMMENDATIONS

None.

APPENDICES

APPENDIX A
Paths taken by aircraft

Figure A-1. Flight path

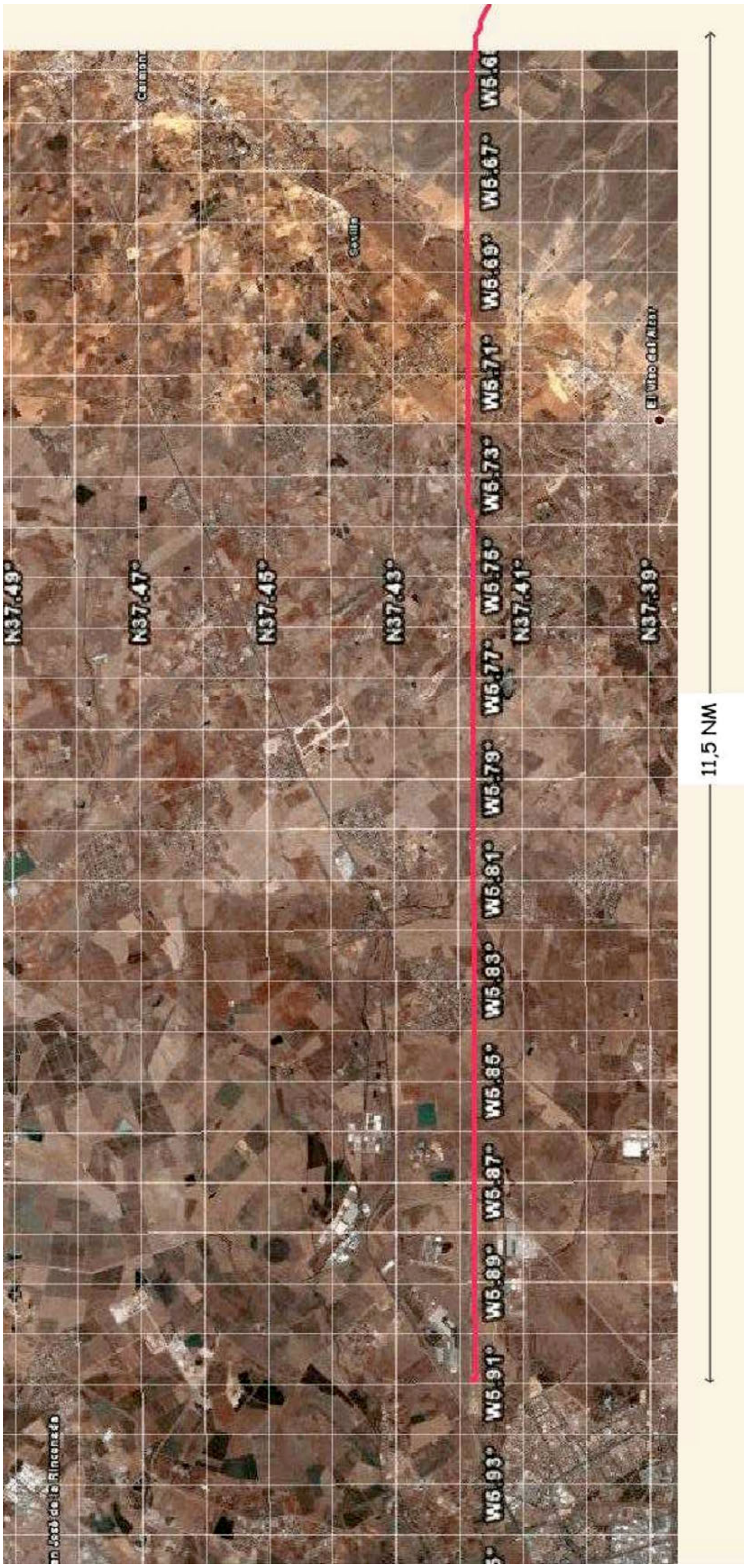


Figure A-2. Path on final approach

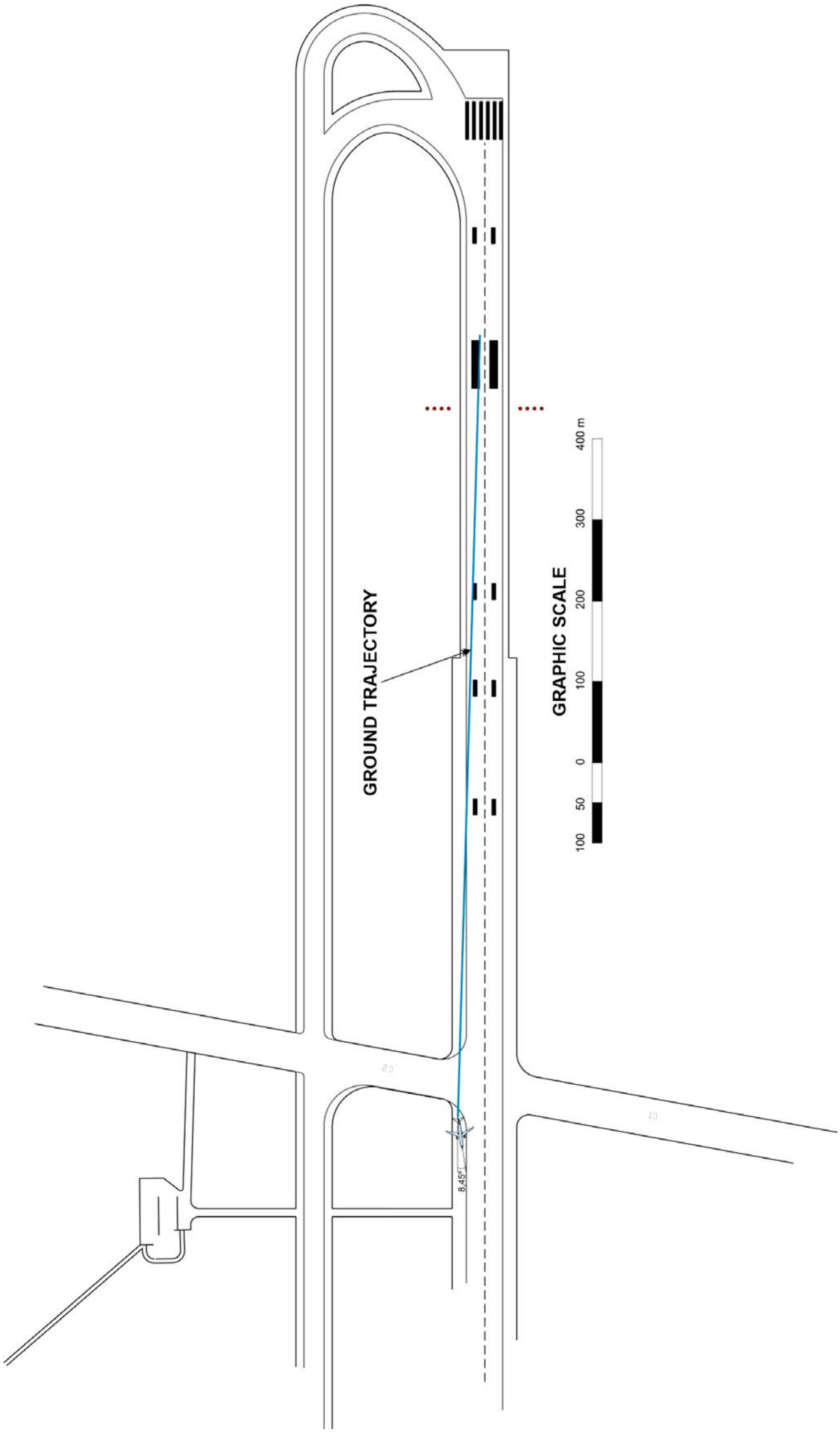
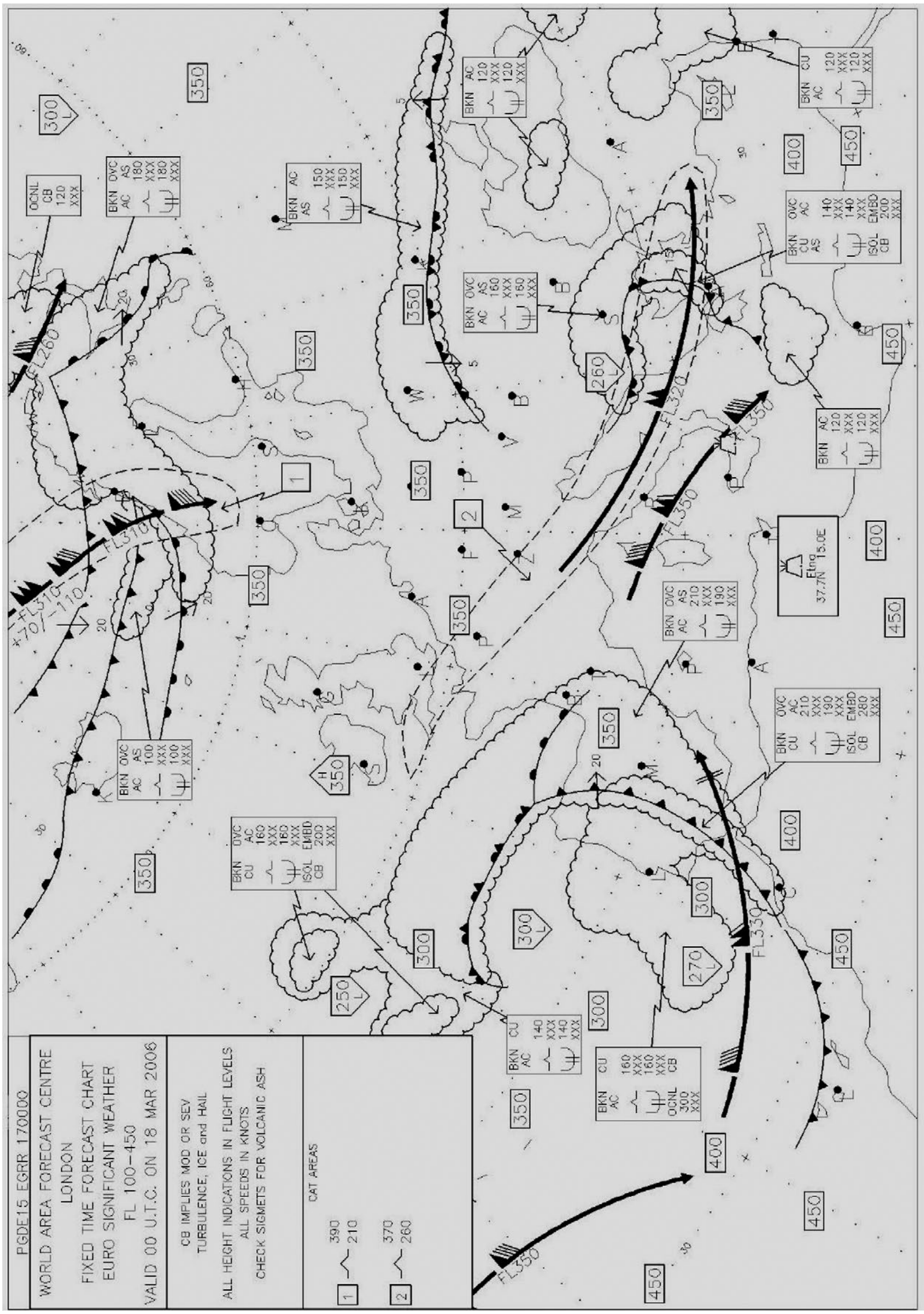
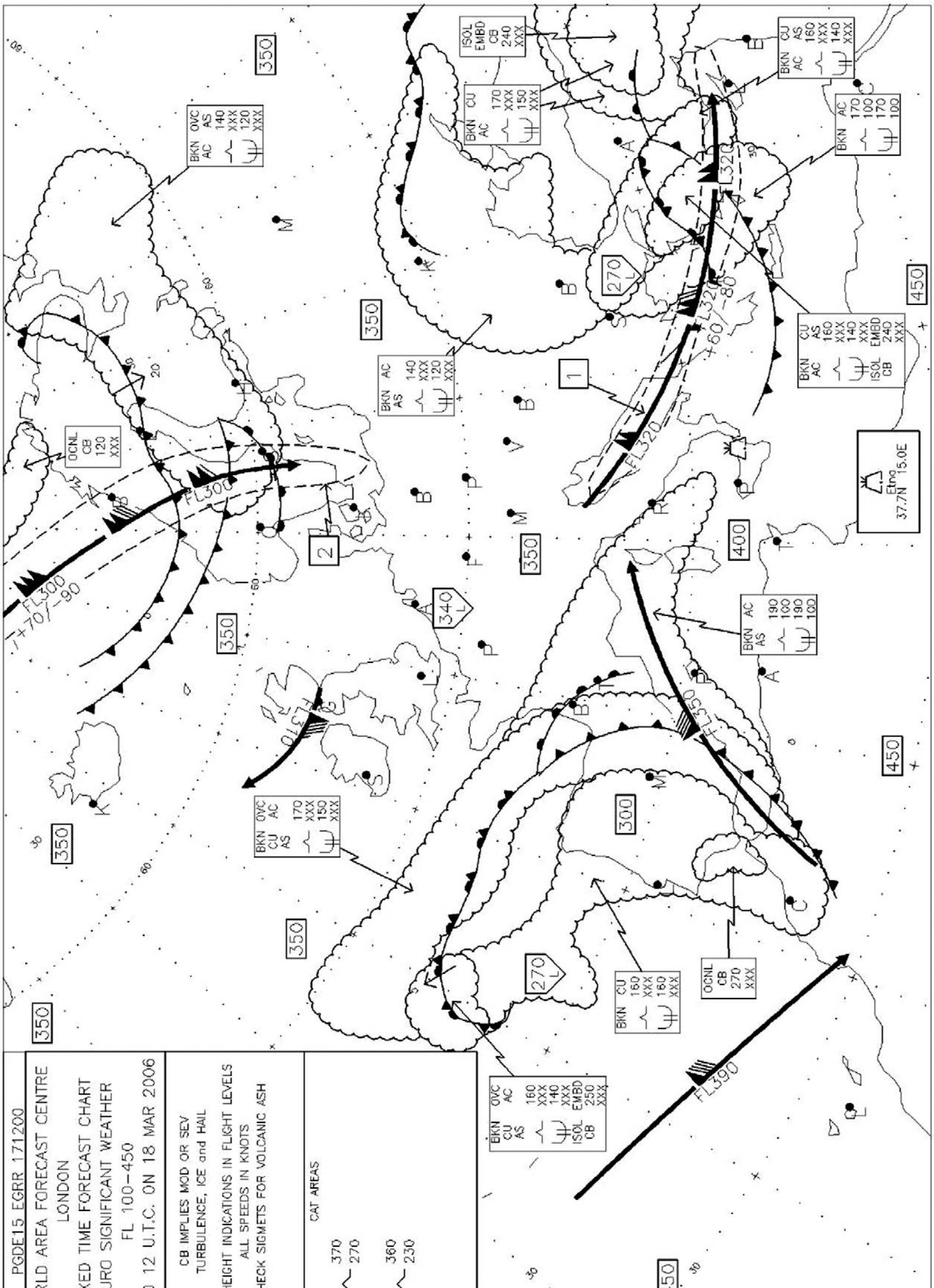
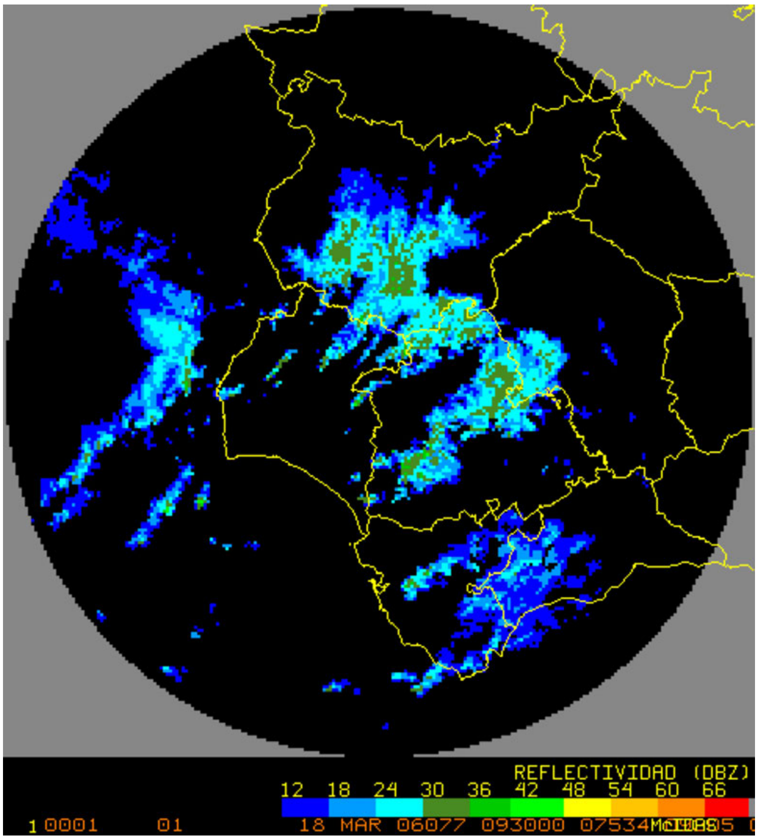


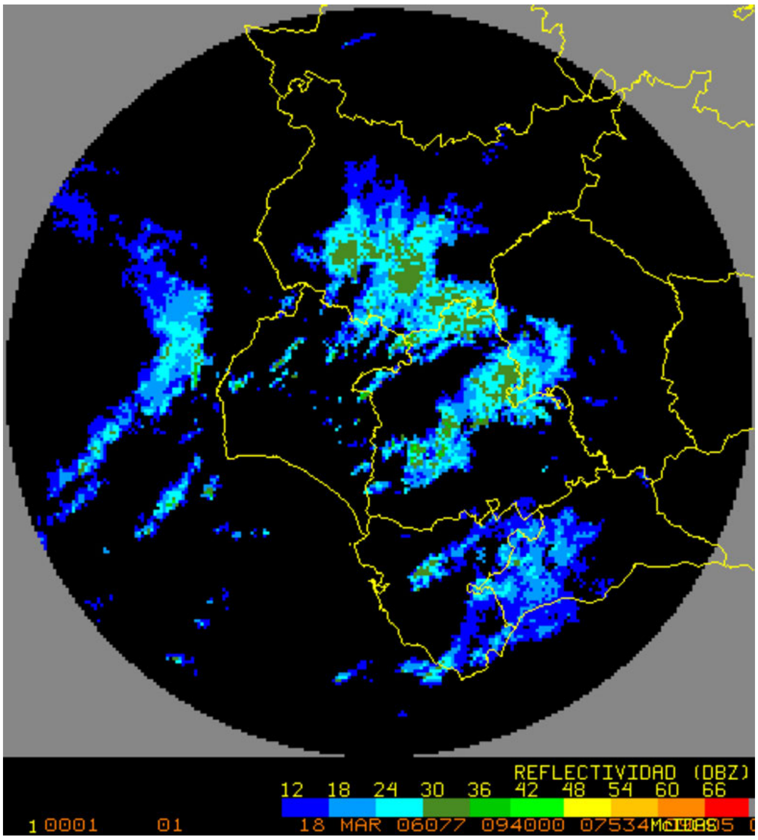
Figure A-3. Path on the ground

APPENDIX B
Meteorology


PGDE15 EGRR 170000
WORLD AREA FORECAST CENTRE
LONDON
FIXED TIME FORECAST CHART
EURO SIGNIFICANT WEATHER
FL 100–450
VALID 00 U.T.C. ON 18 MAR 2006
CB IMPLIES MOD OR SEV
TURBULENCE, ICE and HAIL
ALL HEIGHT INDICATIONS IN FLIGHT LEVELS
ALL SPEEDS IN KNOTS
CHECK SIGMETS FOR VOLCANIC ASH
CAT AREAS


PGDE15 EGRR 171200
WORLD AREA FORECAST CENTRE
LONDON
FIXED TIME FORECAST CHART
EURO SIGNIFICANT WEATHER
FL 100–450
VALID 12 U.T.C. ON 18 MAR 2006
CB IMPLIES MOD OR SEV
TURBULENCE, ICE and HAIL
ALL HEIGHT INDICATIONS IN FLIGHT LEVELS
ALL SPEEDS IN KNOTS
CHECK SIGMETS FOR VOLCANIC ASH
CAT AREAS
1 370 270
2 360 230
FL300
FL320
FL350
FL390
Etna 37.7N 15.0E


REFLECTIVIDAD (DBZ)
12 18 24 30 36 42 48 54 60 66
1 0001 01
18 MAR 06077 093000


REFLECTIVIDAD (DBZ)
12 18 24 30 36 42 48 54 60 66
1 0001 01
18 MAR 06077 094000

APPENDIX C
Aeronautical information (AIP)

AIP
ESPAÑA

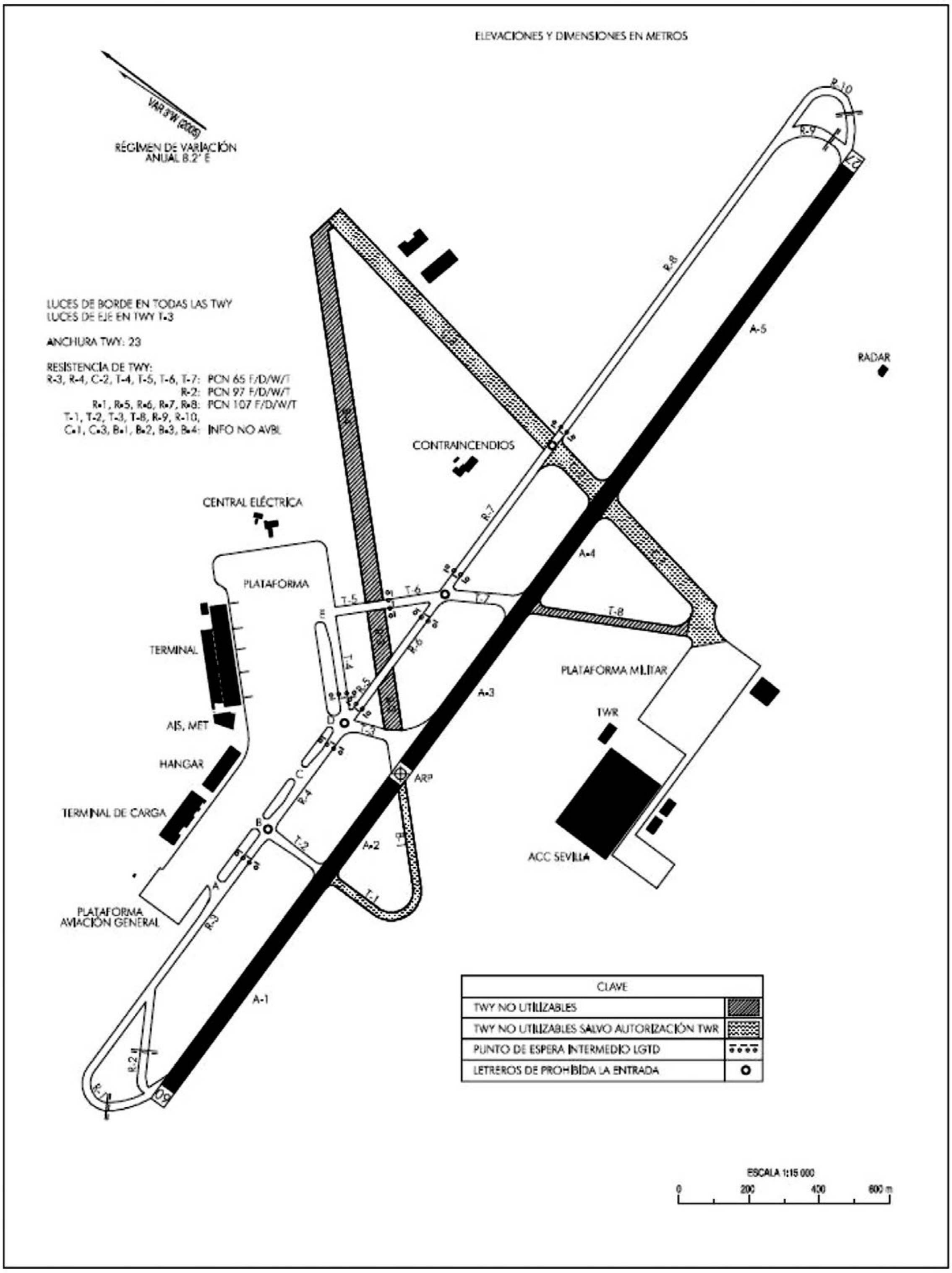
AD 2-LEZL GMC
WEF 12-MAY-05

PLANO DE AERÓDROMO PARA
MOVIMIENTOS EN TIERRA-OACI

ELEV
PLATAFORMA
26.2 m

TWR 118.10
GMC 121.70

SEVILLA



AIS-ESPAÑA

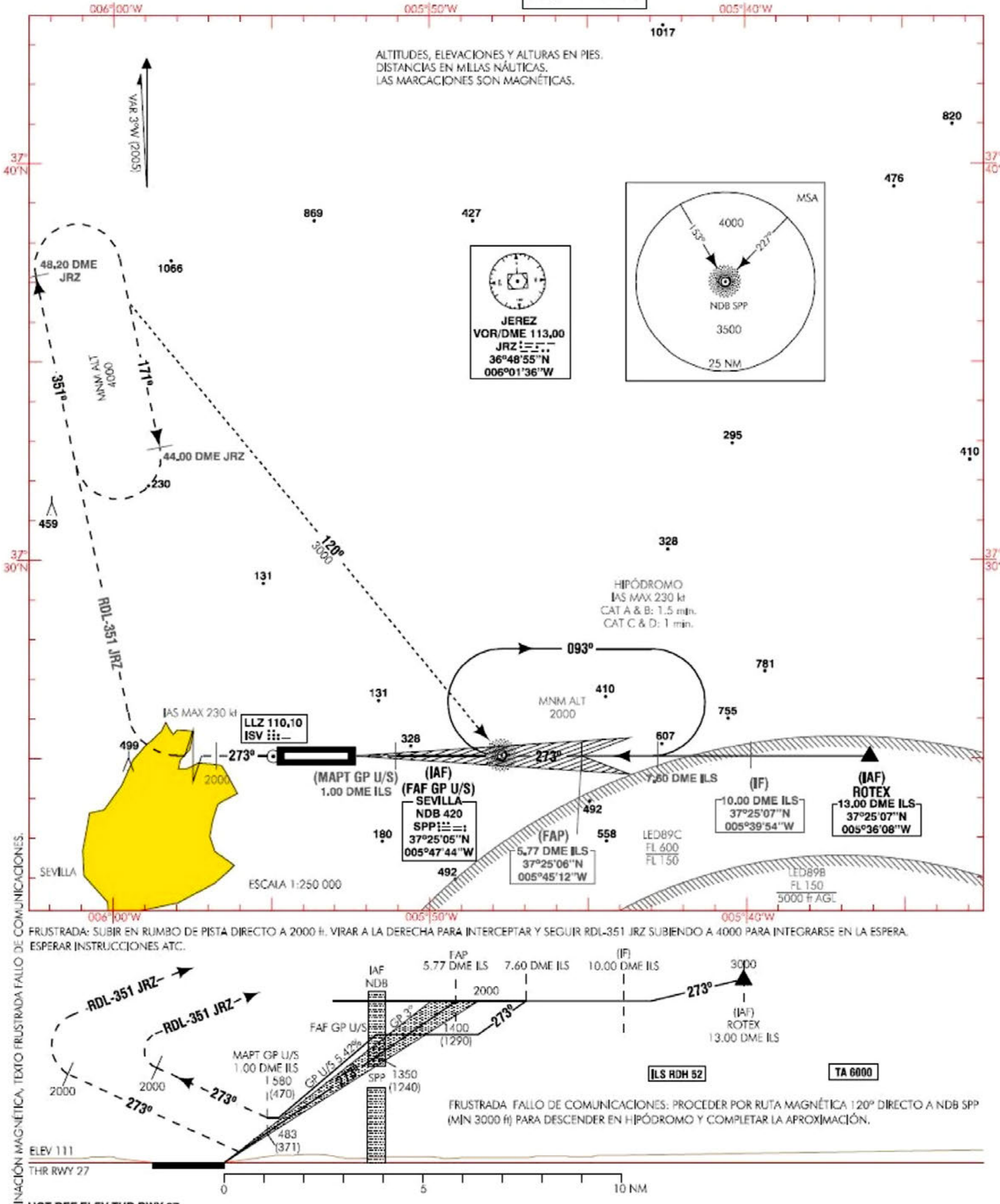
AIRAC AMDT 05/05

CARTA DE APROXIMACIÓN POR INSTRUMENTOS-OACI

ELEV AD 111

APP 128.500
TWR 118.100
GMC 121.700
ATIS 118.175

SEVILLA
NDB-ILS/DME-VOR/DME
RWY 27



HGT REF ELEV THR RWY 27

OCA/H		A	B	C	D
STA	2.5%	298 (187)	310 (199)	318 (207)	329 (218)
	GP U/S	580 (470)			
En circuito (H) sobre 111		630 (520)	630 (520)	990 (880)	990 (880)

GS	kt	80	100	120	140	160	180
FAP-THR; 5,77 NM	min:s	4:20	3:28	2:53	2:28	2:10	1:55
FAF-MAPT: 2.76 NM	min:s	2:04	1:39	1:23	1:11	1:02	0:55
ROD 5.24%	ft/min	425	531	637	743	849	955
ROD GP U/S: 5.42 %	ft/min	439	549	659	768	878	988

ALT/HGT DME (ILS) FNA GP U/S

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
										1160 (1050)	830 (720)	

WEF 12-MAY-05 (AIRAC AMDT 05/05) AIP-ESPAÑA AD 2-LEZL IAC/2

APPENDIX D
Cockpit Voice Recorder.
Highlights from recording transcript

UTC Time	Time (s)	T hh:mm:ss	Station	Content	Remarks
9:05:05	–1.741	0:29:01			
9:05:25	–1.721	0:28:41	ATIS		
9:06:00	–1.686	0:28:06	ATIS	... 160°/12 kt visibility 5000 m	
9:07:35	–1.591	0:26:31	Capt	...	Reads RWY 27 ILS approach and go-around procedures out loud
9:09:25	–1.481	0:24:41	Capt	Descent and approach checklist	
9:09:45	–1.461	0:24:21	Capt	... then 127 132 ...	Reference and go-around speeds
9:10:05	–1.441	0:24:01	Capt	... descent prior to two minutes ... 15°	Flaps position
9:11:25	–1.361	0:22:41	Cop	Sevilla Air Algerie 2652 requesting descent	
9:11:32	–1.354	0:22:34	ATC	2675 Roger. Stand-by	
9:11:37	–1.349	0:22:29	Cop	O.K.	
9:12:03	–1.323	0:22:03	ATC	Air Algerie 2652 descend to flight level 250	
9:14:29	–1.177	0:19:37	Capt	...	Review ground and follow me procedure
9:15:08	–1.138	0:18:58	ATC	Air Algerie 2652 to continue descent contact Seville on 134 decimal 8	
9:15:20	–1.126	0:18:46	Cop	...	Communicates with APP
9:15:25	–1.121	0:18:41	ATC	Air Algerie 2652 ... identified ... continue descent to 190 and proceed direct to ROTEX	
9:17:27	–999	0:16:39	ATC	Air Algerie descend to 170	
9:18:35	–931	0:15:31	Capt	It's getting stormy	
9:19:33	–873	0:14:33	ATC	Air Algerie descend to 150	
9:22:08	–718	0:11:58	ATC	Air Algerie descend to 130	
9:22:45	–681	0:11:21	ATC	Air Algerie 2652 to continue descend contact Seville APP on 120 decimal 8	
9:23:00	–666	0:11:06	APP	... radar contact continue descent to flight level 90	
9:23:05	–661	0:11:01	ATIS	... ATIS information kilo ... visibility 3,000 m RVR in touchdown zone in excess of 2,000 storms with scattered clouds Cb 1,500 ft cloudy at 2,000 ft temperature 14 dewpoint 14 QNH 1,001 ...	
9:23:35	–631	0:10:31	APP	... the storm is over the airfield and you appear to be to the northwest ... you need ... 10 degrees left to avoid the storm	APP responding to other traffic departing Seville
9:23:51	–615	0:10:15	Capt	No ... listen to the weather report... there'll be a storm ...	
9:23:58	–608	0:10:08	APP	... Air Algerie 2652 QNH in Sevilla 1,001 descend to 4,000 ft transition level 75	
9:24:52	–554	0:09:14	Cop	Seville Air Algerie ... storm ... can you specify the procedures	
9:25:07	–539	0:08:59	APP	Air Algerie cleared for ILS approach runway 27 in Seville QNH 1,001 ... at your discretion direct to ROTEX and above ROTEX per your ILS procedures	

UTC Time	Time (s)	T hh:mm:ss	Station	Content	Remarks
9:25:15	–531	0:08:51	Cop	O.K. down four thousand feet cleared for ILS runway 27 Air Algerie	Copilot understands they are cleared to descend to 4,000 ft
9:25:25	–521	0:08:41	Capt	... he gave us 4,000 ... yes ... Yes... he said at your discretion so... we're at 29, we have a way to go still... we'll get there... we're below the glideslope... it's no use... to avoid this...	
9:26:03	–483	0:08:03	Cop	Can we go around to the left? Air Algerie	
9:26:10	–476	0:07:56	APP	Yes at your discretion	
9:26:13	–473	0:07:53	Capt	273 execute ... thanks ... we're here	Reaching the 273 radial ?
9:26:23	–463	0:07:43	Capt	I'll start ... not yet ...we're far away ... at 26 NM ... and 3,500 ...	
9:27:03	–423	0:07:03	Capt	Let's identify them ... you can set dual ILS ...	
9:27:23	–403	0:06:43	Capt	Identified ... I'm afraid this one goes all the way to the field ... until it's "over"	Possible allusion to storm or cloud they are penetrating
9:27:56	–370	0:06:10	Capt	So, 2,000 ft we'll intercept the slope at 5.8 plus 6 make 6 and 6 .. at 12 NM the slope at 4,000 ft ... see? It's getting serious ... but this ...	Probably comments on the calculation of the point where they will capture the slope, above ROTEX and at 4,000 ft, mixed with comments about the weather
9:28:30	–336	0:05:36	APP	Yes sir you can fly at your discretion to intercept the localizer making allowances for the storm ... at your discretion	
9:28:41	–325	0:05:25	APP	Air Algerie 2653 Seville I have no weather information on my screen, sorry	
9:28:52	–314	0:05:14	Capt	Yes ... you said ... No I don't have the slope here ... everything's ok ... So 15 NM we can start to slow because that one... is in our path and getting closer...	
9:29:10	–296	0:04:56	Capt	We'll do it like that ... reduce reach, say 10 or 20 ... it's good at 10 ... we'll get there at the same time ... see ... what can we do	They seem to be speculating that the storm, which they are seeing on the weather radar, will reach the field at the same time as the airplane
9:30:02	–244	0:04:04	APP	Air Algerie contact Tower 118 decimal 1	
9:30:49	–197	0:03:17	TWR	2652 good morning cleared to land runway 27 wind is 240 10 kt	
9:31:05	–181	0:03:01	EGPWS	Twenty five hundred	The EGPWS notifies passing through 2,500 ft
9:31:13	–173	0:02:53	Capt	Yes here it is ... it's starting to ...	
9:31:19	–167	0:02:47	Capt	(Sound of windshield wiper and rainstorm) ... 7 NM see ... we're getting there at the same time ... you see ... see the other one ... wait ... wait a bit longer ... we're far away 7 NM we're going to drag for nothing ... we have to be careful on final with the wind because ... 1,700 ft	
9:31:53	–133	0:02:13	Capt	We'll get there at the same time, you see that? ... 1,500 ft gear down	
9:32:07	–119	0:01:59	Capt	Flaps 15 landing checklist	

UTC Time	Time (s)	T hh:mm:ss	Station	Content	Remarks
9:32:16	–110	0:01:50	Capt y Cop	Altimeter 1001 1500, Speedbrakes armed, landing gear green lights, Flaps 15 green light, runway in sight	
9:32:35	–91	0:01:31	Capt	Wait a second ... I'll give you ... 1,000 ft 30 ... (EGPWS one thousand), landing checklist complete ... 30 green ... O.K. flying in manual recycle "minus 10" ... thanks	
9:33:05	–61	0:01:01	Capt	It's better to continue in manual than ... get the latest wind	
9:33:15	–51	0:00:51	TWR	Wind now 240 15 kt	
9:33:33	–33	0:00:33	Capt	Here we go, this is starting to ... we should take notice that ... the wind ... you're worried about the wind ...	
9:33:37	–29	0:00:29	EGPWS	Five hundred	
9:33:42	–24	0:00:24	Capt	Don't look there please ... stay with me ... stay with me O.K.	
9:33:52	–14	0:00:14	EGPWS	Two hundred	
9:33:57	–9	0:00:09	EGPWS	Minimums	
9:33:59	–7	0:00:07	EGPWS	Sink rate	
9:34:00	–6	0:00:06	EGPWS	Pull up	
9:34:01	–5	0:00:05	EGPWS	Pull up	
9:34:02	–4	0:00:04	EGPWS	Pull up	
9:34:03	–3	0:00:03	EGPWS	Pull up	
9:34:04	–2	0:00:02	EGPWS	Sink rate	
9:34:05	–1	0:00:01	EGPWS	Sink rate	
9:34:06	0	0:00:00		Noise of landing gear impact	
9:34:13	7	0:00:07	JKK6605	Crew of aircraft at runway 27 hold point informs TWR that Air Algerie landing gear was damaged on landing	
9:34:25	19	0:00:19	Capt	Careful	
9:34:40	34	0:00:34	Capt	Careful with the storm	
			TCP	Should we open the doors	
			Capt	We're there... Yes, yes open them	
			TCP	Both of them?	
			Capt	Open the two ... open both ... we're ok for now ... I'm asking you to evacuate as soon as...	
			TCP	Should we evacuate?	
			—	Evacuation, evacuation	
			Capt	No, no ... wait we haven't disconnected yet ...	
9:35:14	68	0:01:08	—	End of recording	

APPENDIX E
Photographs

Photograph 1. General overview of the aircraft

Photograph 2. Right side view

Photograph 3. Left side view. Front part

Photograph 4. Left side view. Rear part

Photograph 5. Left side view. MLG right leg detail

Photograph 6. Passengers cabin. Overhead panel detached