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COMISIÓN DE
INVESTIGACIÓN
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AVIACIÓN **C**IVIL

Technical report
A-006/2001

Accident of aircraft Airbus
A-320-214, registration
EC-HKJ, at Bilbao Airport
on 7 February 2001

MINISTERIO
DE FOMENTO

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TRANSPORTES

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Foreword

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

In accordance with the provisions of Law 21/2003 and Annex 13 to the Convention on International Civil Aviation, the investigation has exclusively a technical nature, without having been targeted at the declaration or assignment of blame or liability. The investigation has been carried out without having necessarily used legal evidence procedures and with no other basic aim than preventing future accidents.

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

This report has originally been issued in Spanish language. This English translation is provided for information purposes only.

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Abbreviations

00 °C	Degrees centigrade
00° 00′ 00″	Degrees, minutes y seconds
Ac	Altocumulus
ACC	Area control center
a_{floor}	AOA for automatic TOGA thrust
AFM	Aircraft flight manual
AIP	Aeronautical international publication
ALPHA-floor	AOA for automatic TOGA thrust
a_{max}	AOA maximum
AOA	Angle of attack
APP	Approach control office
a_{prot}	AOA protection
ATC	Air traffic control
ATSB	Australian Transport Safety Board
CAS	Corrected airspeed
CAT I	OACI Category 1
CB	Cumulonimbus
CI	Cirrus
CTE	Captain
CTR	Control zone
Cu	Cumulus
CVFR	Controlled visual flight rules
CVR	Cockpit voice recorder
DFDR	Digital flight data recorder
DGAC	Spain’s civil aviation authorities
DGAC-F	France’s civil aviation authorities
DH	Decision height
DME	Distance measurement equipment
DOT	Marking of the ILS display
E	East
EFCS	Electronic flight control system
ELAC	Elevator and aileron computer
EPR	Engine pressure ratio
FAP	Final approach point
FBW	Fly by wire
FDR	Flight data recorder
FOT	Flight Operation Telex
ft	Feet
g	Gravity acceleration
GPV	Surveillance and forecast group
GPWS	Ground proximity warning system
h	Hours
hh:mm	Time expressed in hours: minutes
hPa	Hectopascal
IAS	Indicated airspeed
IFR	Instrument flight rules
ILS	Instrument landing system
IMC	Instrument meteorological conditions
INM	National Meteorological Institute
JAR-OPS 1	Joint Aviation Requirements – Operations (commercial aircraft)
km	Kilometer(s)
kt	Knot(s)
m	Meter(s)
MAC	Mean aerodynamic cord
mb	Milibars
MDA	Minimum descent altitude

Abbreviations

MDH	Minimum descent height
METAR	Meteorological trend report
MHz	Megahertz
min	Minute(s)
MM	ILS middle marker
MTOW	Maximum take off weight
N	North
N/A	Not affected
NM	Nautical mile
OIT	Operator Information Telex
OMA	Airport meteorological office
OSTIV	Technical and Scientific gliding aviation organization
P/N	Part Number
QNH	QNH
RA	Radio altimeter
RVR	Runway visual range
S/N	Serial number
Sc	Stratocumulus
SEC	Spoilers and elevator computer
SEI	Fire fighting service («Servicio de extinción de incendios»)
TAF	Terminal area forecast
TAS	True airspeed
TOGA	Take off-go-around power setting
TPM	Cargo public transport
TPP	Passengers public transport
TWR	Control tower
UTC	Universal coordinated time
Vapp	Approach speed
Vls	Lowest selectable speed
VMC	Visual meteorological conditions
VOR	Very high frequency omni-directional range
Vref	Take off reference speed
W	West
WSW	West-South-West

Synopsis

The aircraft Airbus A-320-B, registered EC-HKJ and operated by IBERIA was on a commercial flight under call sign IB-1456 from Barcelona to Bilbao on February 7th, 2001. It found turbulent conditions during the approach phase to its destination at around 22:00 h UTC. On the final approach phase flying below 200 ft radio-altitude the aircraft encountered strong and changing vertical and horizontal gusts while descending at a rate of around 1,200 ft/min (6 m/s).

The aeroplane did not respond to the pilots' commands on the controls to pitch up the aircraft and to reduce the vertical speed on the flare, causing the aircraft to impact against the threshold of the runway in a slight nose-down attitude.

Upon impact, the nose landing gear collapsed, but the aircraft remained within the runway and stopped after 1,100 meters of landing run with all four main gear tires burst. An emergency evacuation was carried out.

A passenger was a seriously injured and several other occupants received some bruises and injuries produced during the evacuation of the aircraft.

The internal structural damages of the airframe were beyond economically viable repair and the aircraft was written off.

The cause of the accident was the activation of the angle of attack protection system which, under a particular combination of vertical gusts and windshear and the simultaneous actions of both crew members on the sidesticks not accounted for in the design, prevented the aeroplane from pitching up and flaring during the landing.

In this report three safety recommendations have been issued, in addition to the preliminary recommendation issued during the initial phase of the accident investigation.

1. FACTUAL INFORMATION

1.1. History of the flight

On February 7 2001, shortly after 22.00 h UTC[1], the aircraft Airbus A-320-B, registered EC-HKJ, was on its final approach to runway 30 of Bilbao Airport. The aircraft, operated by Iberia, was employed on flight IB-1456, a scheduled domestic flight from Barcelona to Bilbao, with 136 passengers and 7 crew members on board. The expected flight time was 53 minutes.

The current conditions in Bilbao were night VMC, with a 10 kt and southwest (SW) wind and gusts of up to 25 kt. Visibility was more than 10 km and there were scattered clouds above 5,600 ft. The sun had set four hours earlier and all electronic and visual aids in the airport were fully operational. There was no rain and the flight was conducted under IFR rules.

Since the take off from Barcelona at 21:01 h, the flight had been uneventfull. The pilot flying was seated on the right hand side, and he was in line flying under supervision. The captain seated on the left hand side was supervising the flight. A third flight crew

[1] Time reference in this report is Coordinated Universal Time (UTC) unless otherwise stated. It is necessary to add one hour to obtain the local time.

member, seated in the jump-seat, was the first officer who had given his seat to the pilot under supervision on the right hand seat.

On course to Bilbao, the aircraft flew over Pamplona at flight level 150, where they were informed of possible light turbulence. At about 25 NM from their destination and at 7,500 ft altitude, they crossed a small cumulus with strong turbulence. Descending through 6,000 ft and established on the Bilbao localizer they found winds of 55 kt. The ATC tower (TWR) of Bilbao cleared them to land on runway 30, and informed of current winds of 8 to 15 kt at 240°, with light turbulence. The aircraft reached the decision height, 247 ft, under VMC conditions and continued the approach to land. One minute prior to touchdown, the tower informed of wind conditions of 240° 8 kt.

The aircraft conditions during the approach were: Weight, 62,380 kg; centre of gravity, 28,66% MAC, full flaps. The reference speed (Vref) was 132 kt and the approach speed (Vapp), 142 kt. Auto-pilot was disconnected by the crew at 400 ft to continue the approach manually.

In the last few seconds prior to touch-down, the vertical descent speed was very high, around 1,200 ft/min (6 m/s) and the «sink rate» warning of the GPWS sounded twice.

The aircraft did not react to the pitch-up order input applied by both pilots on the side-sticks, due to the design software logic that operates at these specific moments, and did not flare. Announcements of «dual-input» warning were heard at the time.

Then the captain, in view of the «sink rate» warnings, selected TOGA power setting to go around and abort the landing.

The pilots' actions on the flight controls could not avoid a hard touchdown of the aircraft in a slight nose down attitude, and the captain decided to continue the landing and to stop the aircraft. The aircraft slowed-down along 1,100 m of the runway within the paved surface. It finally came to a stop with its horizontal axis at an angle of 60° to the right of the runway center line.

During the landing roll the nose landing gear collapsed, the four tires of the main gear burst and the engine nacelles, on which the aircraft was leaning after the collapse, dragged along the pavement.

Once the aircraft came to a halt, the captain ordered its evacuation, which was carried out using all the exit doors and their slides. During the evacuation a cabin crew member and 24 passengers were injured. All injuries were considered minor except for one, a female passenger whose injures were considered serious. Seven injured people were taken to hospital.

1.2. Injuries to persons

Injuries	Crew	Passengers	Total in the aircraft	Others
Fatal				
Serious		1	1	
Minor	1	23	24	Not applicable
None	6	112	118	Not applicable
TOTAL	**7**	**136**	**143**	

1.3. Damage to aircraft

Besides the obvious damage to the engines and nose landing gear, the strong impact of the aircraft on the main landing gear, due to the excessive descent rate in the final approach, produced severe structural damage that caused a total loss of the hull. During touchdown vertical accelerations of up to 4.75 g were recorded.

1.4. Other damage

Minor damage was caused to the runway upon the aircraft's impact and dragging. At the end of the landing roll two runway edge lights were broken.

The aircraft's retrieval and removal from the runway and cleaning operations forced the authorities to close that runway for several hours.

1.5. Personnel information

1.5.1. *Flight crew*

1.5.1.1. Captain

Age/Sex:	42 years/Male
Nationality:	Spanish
License:	Airline Transport Pilot License
Validity:	02-01-2006
Type ratings:	A-320, IFR

Last medical check:	14-12-2000
Last refreshment course:	18-12-2000
Last emergency and safety equipment course:	24-11-2000
Total flight time:	10,805 h

The operator reported that before the date of the accident the captain had passed all the checks and requirements of the DGAC of Spain to become a supervisor and he had also been granted previous authorization from the DGAC to undergo such checks.

1.5.1.2. Pilot in line flying under supervision

Age/Sex:	24 years/Male
Nationality:	Spanish
License:	Commercial Pilot
Validity:	17-04-2001
Last medical check:	04-2000
Total flight time:	423 h

The pilot had completed the type rating course on the Airbus A-320 on 30-12-2000.

1.5.1.3. First officer

Age/Sex:	27 years/Male
Nationality:	Spanish
License:	Commercial Pilot
Validity:	21-02-2001
Type ratings:	A-320, IFR
Last medical check:	25-01-2001
Last refreshment course:	18-11-2000
Last emergency and safety equipment course:	24-11-2000
Total flight time:	2,670 h

1.5.2. *Cabin crew*

Composed of 4 flight attendants.

1.6. Aircraft information

1.6.1. *Airframe*

Make:	Airbus
Model:	A-320-B
Manufacturer serial number:	1278
Year of manufacture:	2000
Registration:	EC-HKJ
MTOW:	73,500 kg
Owner:	Iberia
Operator:	Iberia

The distance between the main gear wheels station and that of the nose gear wheels is 12.64 m.

1.6.2. *Airworthiness certificate*

Number:	4635
Category:	Normal
Use:	TPP, TPM
Date of issue:	29-10-2000
Validity date:	10-08-2001

1.6.3. *Maintenance data*

Total flight hours:	1,149 h
Total cycles:	869
Last annual inspection:	At end of production line
Hours since last annual inspection:	1,149 h

1.6.4. *Engines*

Make:	CFM (General Electric and Snecma)
Model:	CF56-5B4/P
Thrust:	27,000 pounds
Serial number:	Number 1: 779.789 Number 2: 779.790
Last inspection:	At end of production line

1.6.5. *Information on the flight control system of the A-320*

As a new type, a 150 seat, narrow-body twinjet, medium range aircraft, the innovative Airbus A-320, began to fly in commercial operations in 1988.

One of the highlights of its design was the application to civil aviation of the FBW (fly by wire) and the EFCS (Electronic flight control system) concepts.

In this aircraft pilot movement of the flight control levers in the cockpit is not mechanically linked to the flight control surfaces. In the FBW systems the steel cables and conventional mechanical links and rods are replaced by electrical wires. Between these and the flight control surfaces are placed, computers and electrical and hydraulic actuators. The movement of the flight controls in the cockpit does not exactly match certain deflections of the flight control surfaces. In fact, the control column and wheel have been substituted with a small lever known as a «sidestick».

The pilot's and co-pilot's sidesticks move one independently of one another. They are not connected mechanically. So both pilot and co-pilot can be demanding different maneuvers at the same time. The algebraic addition of both sidestick inputs is what the aircraft considers to be the maneuver requested. The flight control force feedback is independent of the aerodynamic forces on the flight control surfaces, and also independent of the forces the other pilot might eventually be applying to his sidestick.

Any pilot can cancel the other pilot's sidestick input by pressing the override button on his sidestick. The last pilot to press this button is the pilot in control, and the other pilot is advised of this fact by a light on his instrument panel. The system provides a «dual input» aural announcement when both sidesticks are used at the same time.

The EFCS of the A-320 has five computers: 2 ELAC (Elevator and Aileron Computer)] and 3 SEC (Spoiler and Elevator Computer). At each moment only one of the computers is in control, meanwhile the integrity of the system is evaluated electronically. In case of error or malfunction the control is handed from one computer to another. The ELAC 2 is the primary computer on the pitch axis, and the ELAC 1 is the primary computer on the roll axis. In case of a ELAC 2 malfunction the control is transferred to ELAC 1, then to SEC 1 and so on.

The computers receive information on the flight parameters, on the aircraft systems, and also on the position of the sidesticks. Algorithms, laws and programmed functions determine the deflection of the flight control surfaces that must be accrued by certain electrical and hydraulic actuators.

The computer software has evolved throughout the operating life of the aircraft. The accident aircraft had a modification status named «ELAC Standard L80».

For a better understanding of the results of the investigation, paragraph 1.6.6 briefly describes some of the particularities of the elevator control system, and further in 1.6.7 the «ALPHA-FLOOR» function is explained.

1.6.6. *Description of the pitch control system*

Pitch control is achieved with two elevator system surfaces, moved by hydraulic actuators.

The horizontal stabilizer can vary its angle of incidence, moved by a screwjack, driven by two hydraulic motors, actuated in turn by one of the three electrical motors available. The hydraulic motors can be actuated directly and with priority with the trim wheel located in the cockpit.

If there are no system malfunctions, the EFCS follows the «normal law». Otherwise, it will follow the «alternate law», the «direct law» o the «mechanical law»[2].

Normal Law

When «normal law» governs the flight controls, the computer provides control to the three axes and it also protects the flight envelope, in order to avoid overloads, and it provides attenuation of maneuvering loads.

[2] Only the normal law is briefly described in this report.

Elevator deflections depend on the situation of the aircraft. Two main modes of operation can be distinguished, «ground mode» and «flight mode». When the aircraft is on the ground there is a direct relationship between the deflection of the sidestick and that of the elevator.

Flight mode

In the «flight mode» (aircraft either at a height of over 50 ft or airborne, with a pitch angle greater than 8°) the sidestick position is understood as a load factor demand, and the elevators are deflected to the exact degree necessary to achieve the requested vertical acceleration. Additionally, the elevator deflection is limited according to certain attitude protection, features load factor protection, high speed protection and high angle of attack (AOA) protection.

AOA protection (high angle of attack protection) ELAC, L80

To prevent the aircraft from entering a stall when violent maneuvers are requested and at angles of attack above a safe value (α_{prot}), the elevator deflection is limited so the angle of attack never exceeds α_{max}. The sidestick input when the AOA protection is active is then no longer related to a load factor input, but rather to an angle of attack between α_{prot} and α_{max}.

Additionally, in these high angle of attack situations, with a tendency toward phugoid movement, studied by longitudinal dynamic stability , in which the aeroplane oscillates between two kinetic and potential energy levels, the EFCS behaves as a damper of the oscillations, commanding appropriate variations of angle of attack in a way that, when the aircraft is slowing down, makes it pitch downward and vice versa.

AOA protection activation: The AOA protection activates when the system foresees that the aircraft can achieve a high angle of attack. The angle of attack «anticipated» by the ELAC L-80 standard, is the actual angle of attack with an increment accounting for what the angle will be an instant later, calculated with the angle of attack increment observed in the previous instant.

The mathematical formula is what follows:

$$\alpha_{anticipated} = \alpha_{actual} + d/dt\,(\alpha) \cdot f > \alpha_{prot}$$

where f is a function of the position of the sidestick that has a value of «1» when the sidestick position is higher than 10° (nose up); has value of «0» when the sidestick position is below 5° (nose up); and for sidestick positions between 5° and 10° the value of f increases linearly from 0 to 1.

α_{prot} and α_{max} depend on the aircraft configuration:

	Flap 3	Flap Full
α_{prot}	14.5°	12.0°
α_{max}	17.5°	15.0°

Flight control law when AOA protection is active

When the AOA protection is active, the elevators move automatically to find an angle of attack for the aeroplane somewhere between α_{prot} and α_{max}, depending on sidestick position, or an angle even smaller if airspeed oscillations are detected.

When the AOA protection is actuated, the horizontal stabilizer movement is restricted in such a way that it can only move between the value it had at the moment of activation and 3,5° nose down.

De-activation of the AOA protection

To de-active the AOA protection the sidestick has to be pushed either to 8° nose down for at least 0.2 seconds or to 0.5° nose down for more than 0.5 seconds with $\alpha < \alpha_{max}$.

As a consequence of this logic in the activation of the elevator flight control, implemented on the ELAC L80 standard computers, it can be stated that: While in flight, if the angle of attack is high, or its value is increasing fast, and at that specific moment the sidestick is pulled fully backwards, the system will detect a very high anticipated angle of attack and, if it is higher than α_{prot}, will activate the AOA protection. Once this protection has been activated, the system will preclude the aircraft from exceeding the maximum angle of attack but, if it also detects that airspeed is diminishing, it will limit even further the possible angle of attack, pitching the aircraft nose down to dampen an eventual phugoid movement.

1.6.7. *Description of the α-floor protection*

The ALPHA FLOOR or α-floor protection consists of an automatic selection of the TOGA (Take Off – Go Around) thrust position when the aircraft reaches a certain value considered as a high angle of attack that is a function of the aircraft configuration.

Flap configuration	0	1-2	3	Full
α-floor	9.5°	15°	14°	13°

The αfloor protection is inhibited during the landing phase below 100 ft RA.

This protection automatically increases the thrust of the engines in emergencies such as windshear encounters or sudden evasive maneuvers.

1.7. Meteorological information

1.7.1. *Official weather forecast and information*

On 7 February at 22:00 h the meteorological office at Bilbao airport issued the following ordinary METAR:

> SAEW LEBB 072200Z 25011G21KT 9999 SCT056 SCT075 13/01 Q1001 TEMPO 25012KT

This means:

— Wind at 250° and 11 kt and with gusts up to 21 kt.
— Visibility greater than 10 km.
— Scattered clouds at 5,600 ft.
— Scattered clouds at 7,500 ft.
— Temperature 13°, dew point 1°.
— QNH: 1,011.
— Temporarily wind at 250° and 12 kt.

Shortly afterwards, at around 22:10 h, coinciding with the time of the accident, the meteorological office at Bilbao airport issued the following special report:

> SPEW LEBB 072210Z 26009G20KT 9999 BKN056 13/01 Q1001 TEMPO 25012KT

This means:

— Wind at 260° and 9 kt and with gusts up to 20 kt.
— Visibility greater than 10 km.
— Broken clouds (5 to 7 oktas) at 5,600 ft.
— Temperature 13°, dew point 1°.
— QNH: 1,001.
— Temporarily wind at 250° and 12 kt.

The Forecast and Surveillance Group issued a TAFOR at 19:04 valid for Bilbao at the time of the accident, as follows:

> FCEW LEBB 071904 230115G25KT 9999 FEW050 PROB30 TEMPO 1904 25025G40KT 5000 TSSHRA SCT040CB SCT060

This means:

— Wind at 230° and 15 kt and with gusts up to 25 kt.
— Visibility greater than 10 km.
— Few clouds at 5,000 ft.

With a 30% probability between 19:00 and 04:00, winds up to 25 kt, and gusts up to 40 kt, reduced visibility down to 5,000 m due to a rain shower, scattered cumulus-nimbus clouds at 4,000 ft and scattered clouds at 6,000 ft.

1.7.2. *Surface winds registered at the moment of the accident*

In the minutes prior to the accident, the windmeter installed close to runway 30 threshold at field level, recorded winds within 5 and 14 kt. The wind direction fluctuated between 210° and 280°.

1.7.3. *Weather information provided by Bilbao TWR*

Fourteen minutes before the landing the TWR notified of possible light turbulence and that the previous aircraft had reported winds at 200° and 7 or 8 kt changing direction from left to right, maintaining 7 kt intensity at all times, QNH 1,001 hPa and a visibility greater than 10 km. Scattered clouds at 5,800 ft, temperature 13 and dew point 1.

Eight minutes before touchdown, wind was reported at 240° between 8 and 15 kt.

One minute before touchdown, the reported wind was still 8 kt at 240°.

1.7.4. *Atmospheric survey*

The National Institute of Meteorology (INM) provided sounding data received from probes sent from Santander (80 km to the west, windward from Bilbao) at the date and previous hours of the accident. Temperature values and high altitude winds were:

Santander's survey on 7 February 2001 at 12:00:

Height (m)	Temperature (°C)	Wind direction	Intensity of the wind (kt)
59	15.2	220°	23
694	10.8	185°	31
1,078	7.1	175°	23
1,277	5.2	178°	34
1,392	5.4	180°	41
1,583	4.2	190°	52
2,324	–0.7	210°	60
2,782	–3.7	210°	52

Santander's survey on 8 February 2001 at 00:00 h.

Height (m)	Temperature (°C)	Wind direction	Intensity of the wind (kt)
59	13.0	220°	23
76	11.6	218°	24
218	10.9	205°	33
449	9.8	214°	38
606	8.5	220°	41
641	8.2	220°	39
668	8.2	221°	38
1,333	2.8	240°	27
1,389	2.4	245°	27
1,836	–1.1	260°	37
2,416	–5.7	249°	42

Because Santander is located windward and 80 km to the west of Bilbao, the registered data give a clear idea of the status at the lower layers of the atmosphere, before being influenced by the terrain.

It can be observed that winds were more or less steady at between 205° and 220°, of moderate intensity at 2,000 ft, and constantly decreasing the lower the altitude.

1.7.5. *Climatology: South-west situation in Bilbao*

With south and southwest winds there is often turbulence surrounding Bilbao airport, from ground level to 5,000 ft, which can become severe.

Under these conditions, precipitation is not very common, with some clouds, usually lenticular altocumulus, and temperatures tend to higher than average on dry days.

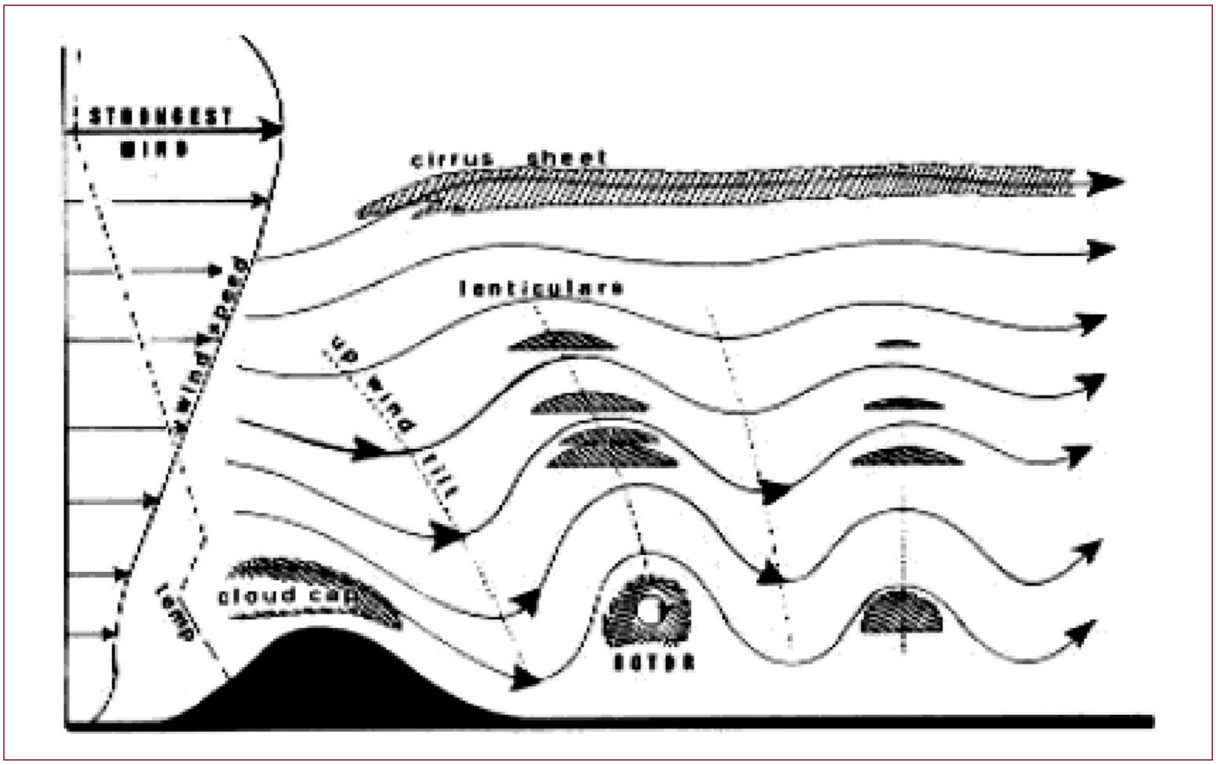
Winds from the south (170°-220°) can gust to more than 40 kt, imposing a great cross-wind component in runway 12/30.

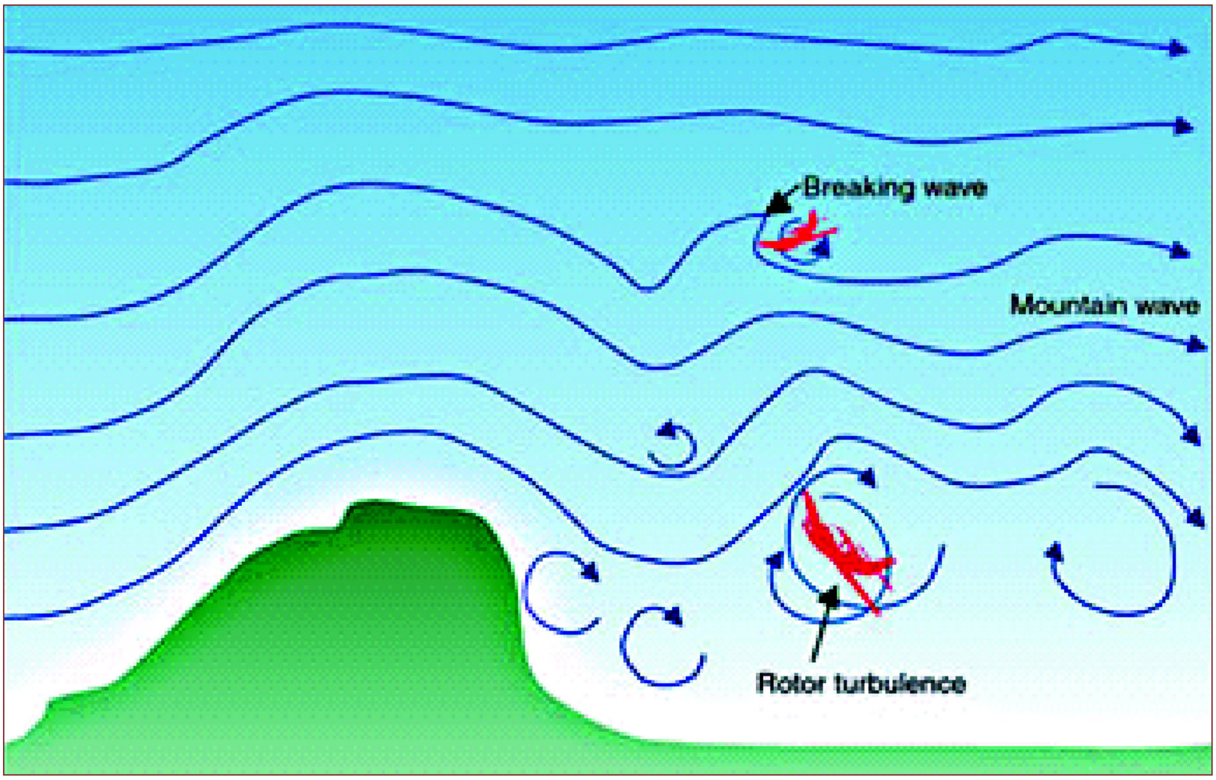
1.7.6. *Mountain Wave*

In certain stable atmosphere conditions, strong winds form perpendicular to a range of mountains, with intensity according to height. The mountain wave phenomenon is generated on the leeward side of the mountains. At high levels the laminar airflow produces waves tipped with lenticular clouds that, depending on the humidity content at each level, may develop, due to condensation, in the climbing part of the wave and dissipate in the descending part.

Eddies and whirlwinds, called rotors, with horizontal axis, parallel to the range of mountains are created at low levels. Rotors are very turbulent and they occasionally go along with cumulus in their highest part. The rotor gets its energy from the lower layers of the wave. Close to the ground the air may take the opposite direction to the direction of the winds at high level. The air then ascends creating a cumulus and closing the circle of its whirlwind.

Images from OSTIV, Mountain Wave Project and from the Australian Transportation Safety Board (ATSB)





1.8. Aids to navigation

Bilbao Airport has a VOR/DME beacon.

Runway 30 is equipped with an ILS CAT 1.

The glide slope (GS) of the ILS has an angle of 3.35°.

1.9. Communications

Normal IFR communications took place during the flight. A transcription of the tape recording was provided by Bilbao airport. The transcription is coincident with the CVR recordings, but it adds some comments between Bilbao TWR and Vitoria TWR about the wind conditions. In the interchange, it is observed that although the wind at ground level seems to be light, from 240° at 8 kt, at higher levels it is «quite bad. With low to moderate turbulence... severe windshear».

The final recordings from the TWR, not registered in the CVR, support the information regarding the times of action of rescue teams as described in paragraphs 1.14 and 1.15.

1.10. Aerodrome information

The Airport of Bilbao's or Sondica is located close to the Cantabric coastline. It has an elevation of 138 ft and is surrounded by mountains and obstacles that have significant influence in the operation.

The mountains and peaks on the south of the airport, with heights up to 4839 ft, frequently produce turbulences when the wind has a southerly component.

It has two runways RWY 10-28 and RWY 12-30 with the following declared distances:

RWY	TORA (m)	TODA (m)	ASDA (m)	LDA (m)
10	2,000	2,250	2,160	2,000
28	2,000	2,055	2,055	2,000
12	2,600	2,650	2,650	2,600
30	2,600	2,600	2,650	2,140

The airport is approved for IFR and VFR traffic.

Runway 30 has a length of 2,600 m and a width of 45 m. At the end of the runway there is a stopway 50 m long and the same width as the runway.

Due to obstacles in the approach path to runway 30, the threshold is displaced 460 m and the remaining landing distance available is 2,140 m.

The magnetic orientation of runway 30 was 297° at the time of the accident.

There are no windshear detectors in the approach areas of the airport.

Appendix B includes an orographic map of the SW area of Bilbao.

1.11. Flight recorders

1.11.1. *Flight data recorder*

The aircraft was equipped with a digital flight data recorder (DFDR) with a recording capacity of more than 450 parameters per second.

Appendix A shows in graphic format the evolution of the recorded parameters used in the analysis.

Graphs 1 and 2 give information on vertical accelerations achieved during the approach and landing phases. Values between 0.7 g and 1.35 g were reached in flight. Upon touchdown the vertical acceleration rose to 4.75 g.

Graphs 3 and 4 show the deviations in DOT[3] from glide slope and localizer during the ILS approach.

In graph 5 the changes in the speed parameters can be seen.

Graphs 6, 7 and 8 represent the pitch angles, the sidestick angles and the elevator angles.

Graph number 9 shows the variation of the recorded angle of attack and the corrected angle of attack[4].

Finally, in graph 10 the engine parameters are represented.

As a guide to the vertical position of the aircraft at every instant, the radio-altitude is included in each graph.

1.11.2. *Cockpit voice recorder*

The CVR recorded the conversations between the pilots and transmissions with APP and TWR, and also several background noises, announcements and warnings.

The recording of cockpit conversations between the pilot and the copilot showed that the aircraft went through a small cumulus, at 25 NM from the airport and at 7,500 ft, whose strong turbulence surprised the pilots, some 10 minutes before touchdown.

It was also noted on this recording that 8 minutes prior to landing, flying at 6,000 ft and 20 NM from the threshold, the aircraft faced a wind of 55 kt.

Five minutes before landing the overspeed warning sounded and they experienced strong air movements.

The crew disconnected the auto-pilot shortly before the radio-altimeter call-out for 400 ft.

Then there were several «dual-input» announcements, advising that both pilots were moving their respective sidesticks at the same time.

[3] DOT refers to the marking of the ILS flight instruments that correspond to angular deviations of approximately 1/4 of a degree in glide slope and 1 + 1/4 of a degree in localizer per each DOT unit.
[4] The angle of attack has been corrected with the formula: $AOA\ cor = AOA \times 0.5333 + 2.4$.

1.12. Wreckage and impact information

1.12.1. *Marks on the runway*

The tire tracks observed on the runway begin 130 m downward from the displaced runway 30 threshold. The tracks correlate to the two legs of the main landing gear, centered on the runway, with the left gear track located upon the runway centerline.

At 3.5 m from the beginning of these marks, which are clearly visible for 40 m, the nose gear tracks appear, but they only extend 10.5 m before turning into scratches and deep grooves of hard metal parts of the nose gear system dragging on the runway surface. Those tracks extend about 5 m and then disappear.

After the marks mentioned above and traces and within a length of about 280 m, only small and discontinuous marks are noticed, which seem to belong to the main gear doors that had fallen off. From there on, at 300 m from impact zone, the marks of the contact of both engines nacelles with the runway appear and 3 m farther the scratches and deep grooves from the nose gear reappear again.

Tracks from the engines and the nose gear continue until the final position of the aircraft when it came to a stop, some 1,100 m from the initial impact point. At the point where the trajectory veers to the left, some 500 m after the appearance of the engines marks, the tracks of the main gear tires are noted again, possibly due to the lateral slipping of the aircraft, whose tires might have blown after that moment. The marks continued up to the end of the trajectory of the aircraft (see Appendix B).

1.12.2. *Aircraft damage*

The nose gear collapsed rearwards, its leg adopting a position at an angle of 45° with respect to the longitudinal axis of the aircraft. The wheels detached in fragments and the wheel axle was abraded by the contact with the runway. The nose gear doors broke off.

All four main gear wheels burst. The gear doors suffered several points of damage.

Both engines suffered from the rubbing contact of the cowling with the runway, damaging the fan blades and the accessory gearbox.

Structural damage was indicated by the deformation of a frame at the front part of the airframe.

It was suspected that during the event important structural damages could have occurred due to the high load factor achieved, 4.75 g according to the DFDR. Subsequent internal damage assessment, led to consider the damage beyond economically viable repair and therefore the aircraft was written off.

Collapsed nose gear detail

1.13. Medical and pathological information

The injured occupants were attended by the Medical Services of Bilbao airport. From the internal communications of this service it is concluded that:

— One flight attendant and 24 passengers suffered traumatisms and contusions.
— Two passengers were diagnosed as having possible fractures.
— 7 injured people received hospital attention.
— 15 out of 25 injured occupants were women.
— 19 out of 25 injured people were older than 57 years of age.
— 22 out of 25 injured people were women or older than 57 years old.

It was estimated that all injuries occurred during the evacuation phase.

1.14. Fire

There was no fire. The Firefighting Service (SEI) entered the runway within 40 seconds and went to the area where the aircraft stopped. They positioned a vehicle at either side of the aeroplane, and sprayed the landing gears and the engines with retardant foam.

1.15. Survival aspects

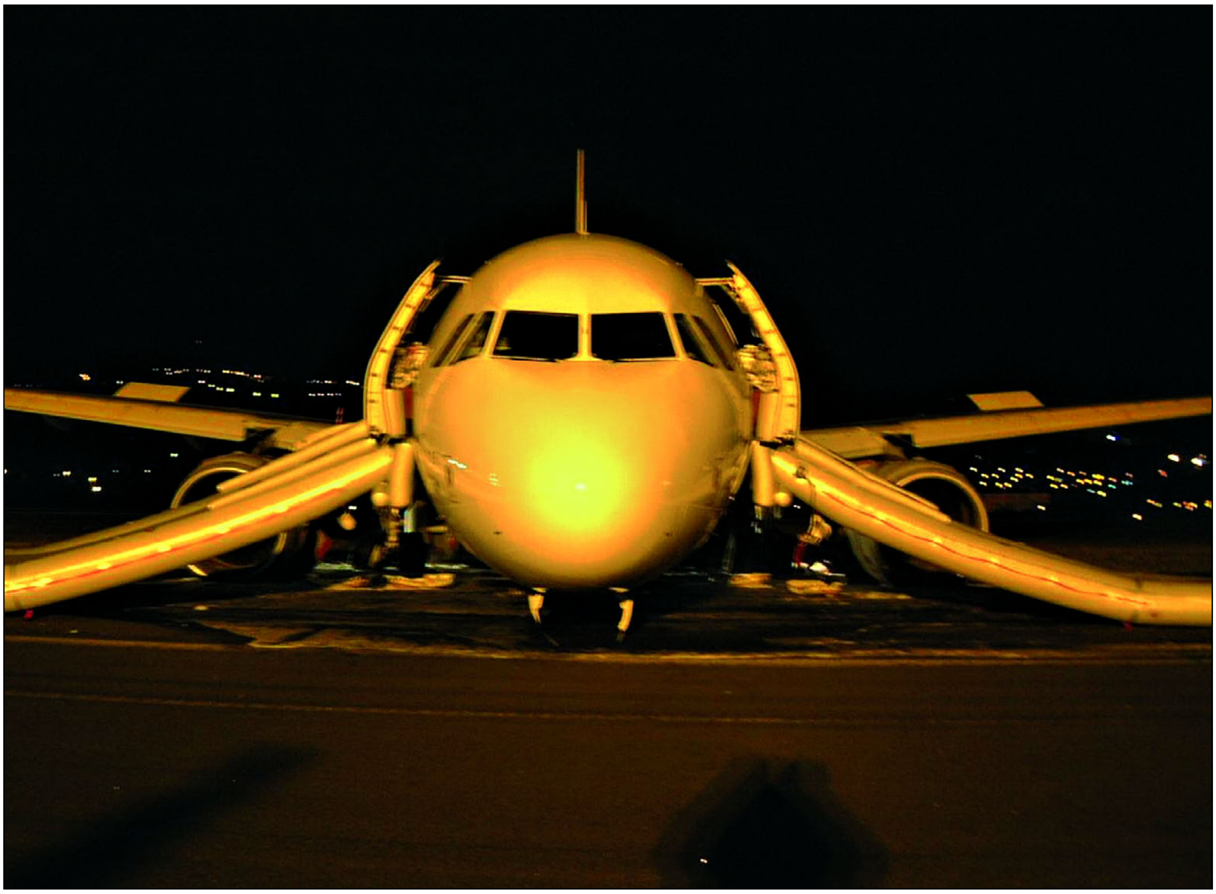
The crew requested help from the fire-brigade one minute after declaring the emergency. The minute later, they discontinued radio communications and all the crew members were dedicated to the evacuation procedures.

All the emergency exits were used, i.e. the two forward doors, the rear doors, and the 4 overwing exits and the corresponding slides.

There were some reports of possible confusion during the evacuation. Inside the aircraft there was a group of around 40 elderly people who were reportedly «run over by the younger passengers that did not respect orders or the procedures».

1.16. Tests and research

The DFDR recording was provided to the aircraft manufacturer and they analysed the flight parameters with the aid of computer simulation tools. The differences between the behavior of the aircraft in the simulation and in the accident flight as recorded in the DFDR, allowed them to calculate the vertical and horizontal components of the wind.



Then they introduced data on the position of the sidesticks and the previously calculated winds into the simulation computer. The results of this second simulation showed that in both cases, simulated and real flight, the aircraft behavior was identical. The logical conclusion was that the aeroplane behaved during the accident flight as designed and therefore the AOA protection was activated not allowing the flare and pitch up of the aircraft.

The vertical gusts caused very fast AOA increments. The ELAC L80 software included an anticipation factor or «phase advance» as a function of the rate of increase of the AOA. This factor was responsible, in this case, for the activation of the AOA protection. This was further confirmed because in simulations done with previous standards to ELAC L80, which do not have that anticipation factor, it was not possible to reproduce the accident aircraft behavior.

The «phase advance» term was introduced to provide an earlier activation of the AOA protection in case of very aggressive flight maneuvers by the pilot.

1.17. Organizational and management information

1.17.1. *Procedures of the operator at Bilbao Airport*

The company that operated this flight, which usually uses this airport, includes in the operations manual (OM) the following note applicable to Bilbao airport:

> «1. Caution:
>
> When there is wind between 160° and 230° higher than 15 kt, expect turbulence and wind-shear during approach and landing.
>
> It is recommended that, when the intensity is higher than 20 kt and there are no reasonably positive PIREPS, no operations are to be carried out at this airport.»

1.17.2. *Role of the copilot in line flying under supervision*

The operator's OM, valid since 07-FEB-2001, assigned to trainee copilots in line flying under supervision the same functions and privileges as included in their DGAC flight license.

1.17.3. *Flight crew requirements in passenger flights*

The Joint Aviation Requirements JAR-OPS-1, Commercial Air Transportation - Aeroplanes, in its Subpart N currently establish that the operator shall ensure that all the crew members hold an applicable and valid license, and that procedures are established to prevent crew composition lacking adequate flight experience. According to Appendix 1 to JAR-OPS 1.1045, dealing with the requirements of the Operation Manual of the commercial air transport operators, this manual must contain «a description of the required license, rating(s),qualification/competency (e.g. for routes and aerodromes), experience, training, checking and recency for operations personnel to conduct their duties»; these requirements being also applicable to crew members acting as pilots under supervision.

Type rating courses according to the JAR-FCL are required, as well as conversion courses, line flying under supervision and line checks. The operations manual, approved by the aeronautical authorities, must cover different aspects like: minimum number of crew members, minimum level of qualifications and experience before beginning the conversion courses, training programs and periodic checks, etc.

When the accident occurred, the requirements in force for obtaining type ratings were included in Circular 15-B.

This document requested theoretical and practical instruction, both in simulator and actual instruction flights, with a type rating check that had to be passed before the issuance of the type rating of the pilot.

The pilot license had to include the current type ratings and the privileges the holder had (pilot in command or co-pilot) with the corresponding limitations in the flights during the phase of line flying under supervision.

Additionally, «each operator will include in its training procedures the policy for line flying under supervision».

Paragraph 6 of Circular 15-B also indicated that «On the other hand, with reference to the type rating as pilot in command, there will be temporary restrictions that must be explicitly included in the [basic operations manual]».

1.18. Additional information

1.18.1. *Preliminary safety recommendation*

Due to this accident, on the 12th of March of 2001 the Spanish «Comisión de Investigación de Accidentes e Incidentes de Aviación Civil» and the French «Bureau Enquêtes-Accidents», issued the following preliminary safety recommendation addressed to the Certification Authority of this type of aircraft, the «Direction Generale de l'Aviation Civile» of France:

> «To define with the manufacturer and to immediately issue, safety measures to prevent the repetition of this kind of events in aircraft of the A-320 family and in other aircraft equipped with similar flight control systems.»

1.18.2. *Temporary operational measures*

To fulfil the period of time until the new ELAC software modifications were in place, Airbus Industries issued on the 23rd of March the OIT/FOT999.0036/01. This publication was the subject of a telegraphic airworthiness directive issued by the French Civil Aviation Authority (Ref.: 15/01 – GSAC-T; Date: 26 March 2001).

These documents introduce the following temporary procedures, which are included in the AFM of the A-320 and the A-319 equipped with the standard ELAC-L80:

> FOR APPROACH TO RUNWAYS KNOWN TO SUFFER GUSTY CONDITIONS, ESPECIALLY IF THESE CONDITIONS GENERATE VERTICAL GUSTS DUE TO THE SURROUNDING TERRAIN,
>
> OR
>
> –REPORTED GUST WIND INCREMENT (MAX. WIND MINUS AVERAGE WIND) HIGHER THAN 10 KT,
>
> OR
>
> –MODERATE TO SEVERE TURBULENCE EXPECTED ON SHORT FINAL,
>
> THE FLIGHT CREW SHOULD STRICTLY ADHERE TO THE FOLLOWING PROCEDURE:
>
> –USE CONF 3 FOR APPROACH AND LANDING,
>
> –MINIMUM VAPP IS VLS + 10 KT; THE RECOMMENDATION TO USE MANAGED SPEED REMAINS VALID,
>
> –CORRECT THE LANDING DISTANCE FOR THE SPEED INCREMENT,
>
> –IF «SINK RATE» GPWS WARNING OCCURS BELOW 200 FT, IMMEDIATELY INITIATE A GO AROUND.

1.18.3. *Corrective actions by Airbus*

Airbus Industrie developed a new standard for the ELAC, standard L81, to modify the logic in the AOA protection in case of turbulent conditions. The new standard was certified by mid 2001, and the corresponding Service Bulletin was published in September 2001. The software modification, considered mandatory by the aeronautical authority, had to be incorporated into all A-319s, A-320s and A-321s before December 2002.

The software modifications to the ELAC included two actions that affect the activation and de-activation of the AOA described in paragraph 1.6. above.

1.° Activation of the AOA protection:

The derivative anticipation term of the angle of attack by the AOA is cancelled (not applicable to the A-319 as activation does not depend on the speed of variation of the angle of attack).

2.° Deactivation of the AOA protection:

Below 200 ft a de-activation condition is added to cancel the AOA protection. The AOA protection is also deactivated when the sidestick is between its neutral position and «–8° nose up" with $\alpha < \alpha_{prot}$ - 2 (ALPHA < ALPHA PROT-2 degrees).

With these modifications the protection level is maintained against dynamically aggressive manoeuvres made by the pilot, but the premature activation of the AOA protection triggered by wind gusts is inhibited, and a de-activation in flight at low height under less stringent conditions is allowed.

1.18.4. *Other testimonies on the accident*

Eye witnesses saw the plane approach in a nose down attitude.

At the end of the landing run they saw smoke and gases coming out from the landing gear.

The Bilbao TWR logbook on 7 February 2001 records that between 15.10 and 16:59 h three aircraft executed a turn-around and went to Vitoria airport, and three other decided to fly directly to Vitoria without any attempt to approach Bilbao.

During the 60 minutes prior to the accident five other aircraft landed at Bilbao without incident.

1.18.5. *Other related accidents and incidents*

Because of its possible similarities as to weather conditions in Bilbao's airspace, it is worth mentioning that on the 23rd of January of the same year, 15 days prior to this accident, there was an incident affecting an Embraer RJ145. This aircraft found turbulence on its final approach to runway 30, which occasioned a long landing that resulted in a runway overrun at 12 threshold. The wind was also from the South and Southwest.

In relation to the aircraft's type, the AOA protection activated incorrectly in one other known occasion:

— On 24 September 1999, an A-320 landing in St. John (Canada), touched down before the displaced threshold, colliding with construction barriers. There were no victims. It was a turbulent, nighttime approach, with vertical and horizontal gusts. The AOA activation did not allow a gentle flare. Among the causes of the accident, optical illusions and a late recognition of the unsafe condition were mentioned (Report A99A0131 from the Transport Safety Board of Canada refers).

2. ANALYSIS

2.1. Final approach glide

The flight was normal until the aircraft was established on the final approach glide path for runway 30 in Bilbao. Due to obstacles on the glide path, the glide slope is 3.35° degrees, higher that the standard 3°, and the threshold is displaced 460 m.

In the approach airspace there was turbulence as evidenced by the recorded vertical acceleration between 0.7 and 1.35 g (see graphs 1 and 2 in Appendix A). Weather conditions were the typical ones usually associated with mountain wave rotors.

The climbing and descending stages of the rotors produce vertical speed changes in aircraft that fly through them, or AOA variations if they have great inertia.

While descending, an aircraft may go through horizontal zones of the rotors and may encounter windshear.

During its approach, aircraft A-320 flying under call-sign IB-1456 on 7 February 2001, found strong winds of 55 kt at around 6,000 ft of altitude. Strong movements and over-speed warnings alerted the crew of the turbulence and windshear conditions that could also have been expected from the TAF issued by the meteorological services, although the METAR and the TWR information only informed of wind intensity from 8 to 12 kt. The crew managed to get an acceptable reading of the glideslope (see graphs 3 and 4 in Appendix A).

The crew continued the approach with a quite stable speed of 142 kt of ground speed, but with calibrated airspeed (CAS) fluctuations of +/– 6 kt, according to the DFDR data. The mean CAS was 145 kt, equivalent to Vref + 13 kt.

Upon passing the 200 ft level as they descended, they found a first gradient of tailwind. Later, before reaching 100 ft, they found a vertical updraft recorded as an acceleration of 1.15 g. The AOA was around 10°.

Then, in the interval of 5 seconds until the touchdown, they encountered a descending draft with a sudden decrease of the AOA in 5°, followed by another strong updraft. A new gradient of tailwind, while passing through 80 ft RA, reduced the CAS in 6 kt within the first second and in 3 kt in the next three seconds interval. Vertical acceleration became 0.82 g.

The aircraft configuration and the operation were at all time in accordance with established procedures, while the aircraft was attempting to remain on the glideslope.

When the aircraft found the updraft, the pilot flying pushed his sidestick, and afterwards he pulled it when he entered the down-draft.

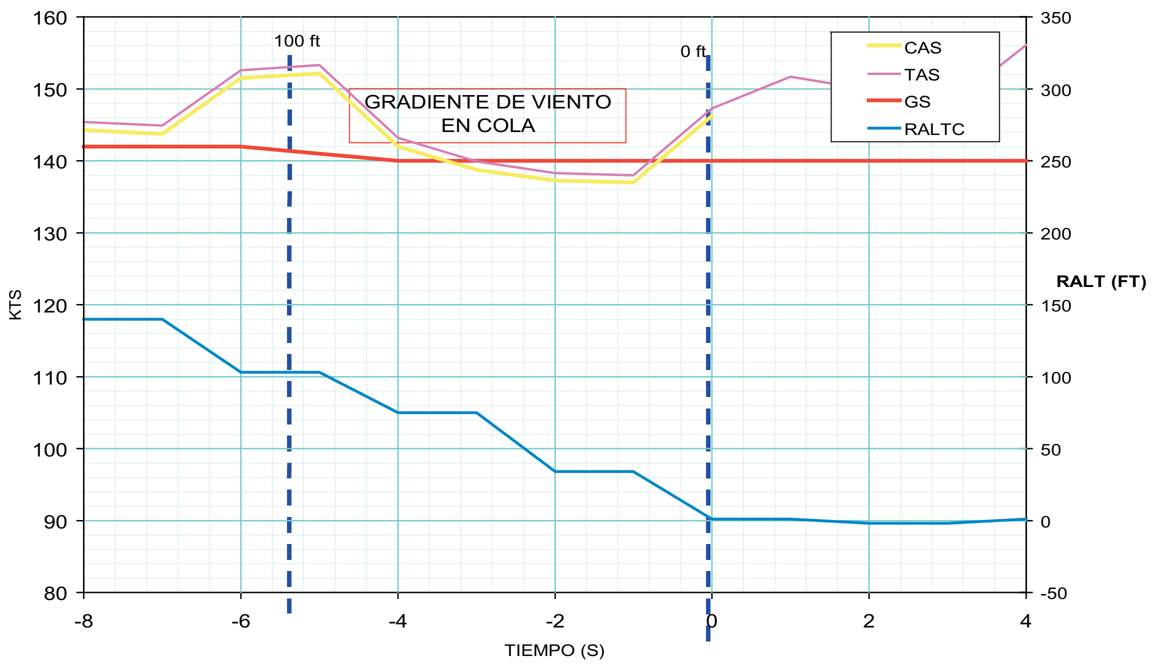


Figure 2.1.1. Speed changes during the last seconds

The captain also pulled his sidestick backwards, adding his input to the co-pilot's. The sum of both inputs soon exceeded 10° of nose-up sidestick position. Under that situation, the logic of the EFCS system gave complete priority to the term of the rate of change of AOA anticipating a high and dangerous AOA, close to stall.

The rapid increase of the AOA, together with both sidestick inputs, caused the activation of the AOA protection.

However, the actual AOA never went higher than 10°, and therefore it remained under the 15° limit for AOA in FULL configuration. The α_{prot} value of 12° would have been exceeded only in the case of the addition of the AOA rate-of-change term being very high for some fraction of a second. The mean value of the AOA rate of change in the critical second was 3 or 4 degrees per second.

The AOA protection status remained active down to runway touch-down because the sidestick pull input was never released and the software logical conditions to deactivate it were never met.

The AOA protection activation was followed by a tail-wind gradient that produced a reduction in the airspeed. This reduction could have been interpreted by the EFCS automatisms as a phugoid movement, which would have resulted in an automatic nose down input just as the aircraft hit the runway.

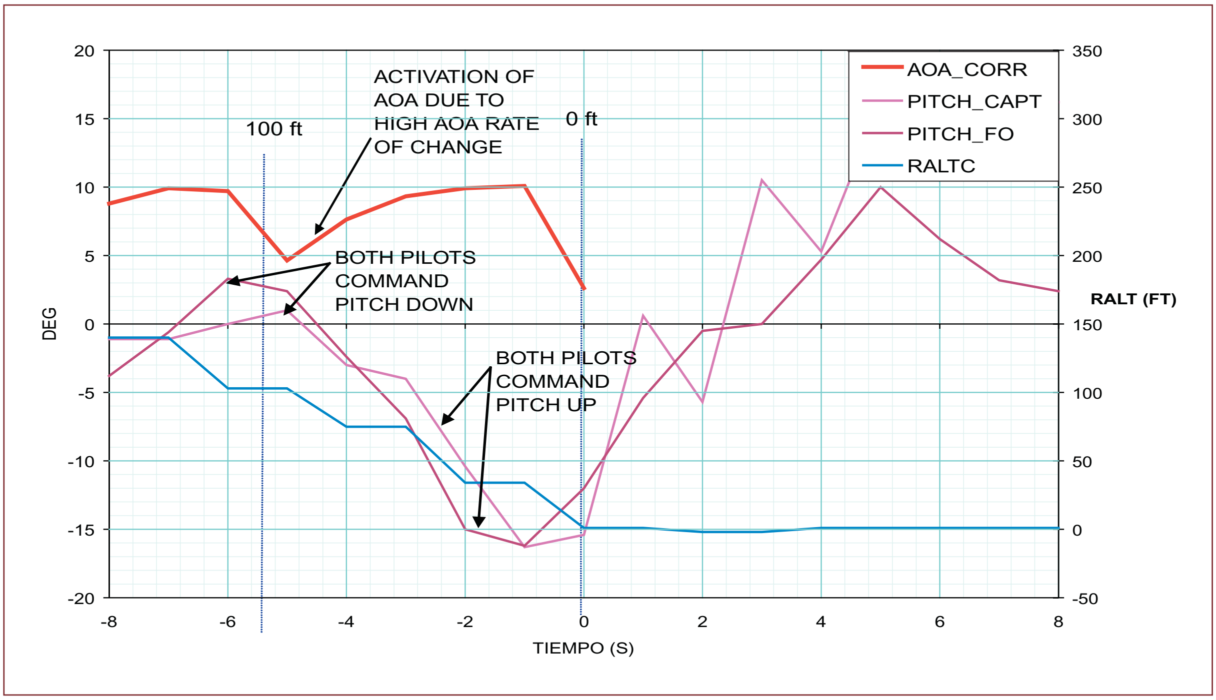


Figure 2.1.2. Change of AOA and sidestick actions of the pilots

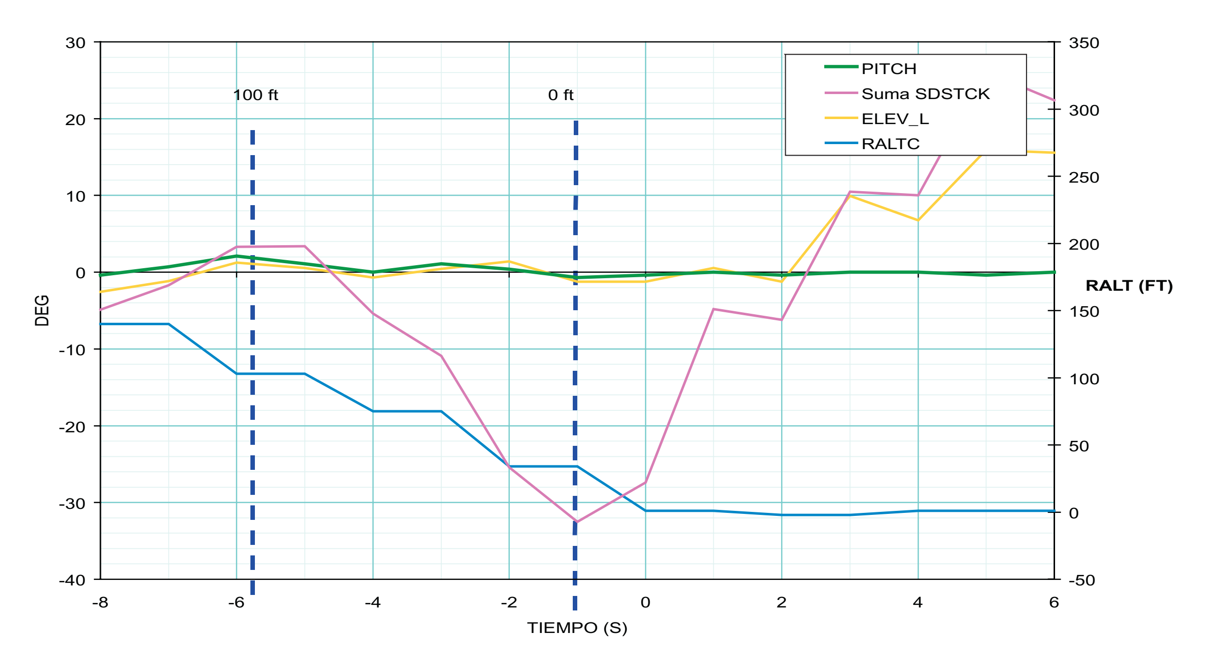
The angle of attack increased again to 10° but the aircraft was not flaring, and the descent rate in the seconds prior to touchdown was 1,200 ft/min. The high descent rate was also influenced by the higher approach speed, due to the wind and the ILS glide slope angle of 3.35°, in addition to the special weather conditions present during the approach.

At that moment there were two «sink rate» warnings and a «dual input» warning advising that both pilots were moving their sidesticks. At less than 50 ft height the crew selected the TOGA power in an attempt to abort the landing. The inertia of the engines on idle thrust setting and the low angle of the elevators did not allow any control of the high descent rate nor initiation of a climb. The aircraft touched down very hard.

It can be seen in Figure 2.1.3 that both sidestick inputs (Suma Sidestick) cannot deflect the left elevator (Elev-L) more than 3°, and thus the aircraft pitch angle does not change and remains under 2° all the time.

Under these wind conditions and with the sidestick actions described above, the response of the aeroplane is coherent with the logic of the flight controls system described in paragraph 1.6.6 that corresponds to the ELAC standard 80.

The accident made it evident that the logic of the AOA protection activation, with an anticipation term of the angle of attack, valid and appropriate in other phases of the flight, is not appropriate in the phase of short final approach.



Note: Negative values of Suma SDSTCK mean positions of sidestick demanding pitch up.

Figure 2.1.3. Response of the aircraft to the sidestick movement: Deflection of the LH elevator and changes in pitch angle

2.2. Touchdown and braking action

The nose down attitude upon first contact is indicated not only by the DFDR but also by eye witnesses and by the proximity of the tires marks from the nose gear and main gear. Since the distance between the axles of the main gear and nose gear is 12.64 m and the distance between the traces is only 3.5 m, it can be concluded that the aircraft covered 9 m between the nose gear impact and the main gear impact, confirming the steep trajectory and a high rate of descent.

Effectively during the hard and jarring ground impact of the main landing gear, vertical accelerations of up to 4.75 g were recorded, instead of the usual values of around 1 g in normal landings, and the cause was the high descent rate of 1,200 ft/min (6 m/s) prior to touch down.

The short nose gear tire marks, barely 10.5 m long, before turning into metal scrapes, indicate that the gear collapsed instantaneously. At around 145 kt (75 m/s) it takes little more than a tenth of a second to cover 10.5 m.

After that first impact, the nose gear was raised, as evidenced by the absence of nose scrape marks. When passing to «ground mode» (de-activation of the AOA protection), the aircraft regained control in the pitch axis, and would slightly raise the nose. Later on, after aerodynamic forces declined, the nose descended slowly, beyond its normal position due to the previous nose gear collapse, and at that moment the engine nacelles made contact with the runway as did again the metal parts of the nose leg.

The main gear wheels remained in place for most of the landing run, while aerodynamic forces allowed positive lateral control. At the end of the landing run, without the nose wheel and without lateral control, the aircraft yawed on the runway and its main tires burst (some eyewitnesses saw smoke and gases by the end of its trajectory).

The 1,100 m of distance travelled by the aircraft in the landing run is what can be expected taking into account the actual weight, speed and braking conditions. Additionally it has to be considered that the aircraft increased its momentum at the initial landing stages because TOGA thrust was selected for around 4 seconds.

The structure of the aircraft did not collapse and protected the passenger cabin, but received internal damage beyond economically viable repair. The ground loads exceeded the design loads.

2.3. Other contributing circumstances

Besides the combination of up and down drafts, and the head and tailwind windshear, other circumstances influenced the accident sequence:

Difficulties began when the aircraft descended through 100 ft RA. If the windshear had appeared higher, the TOGA setting would probably have been triggered by the alpha-floor protection.

If the configuration of the aircraft had been FLAP 3, the α_{prot} value would have been higher and maybe would not have triggered the AOA protection status.

If both pilots had not pulled both sidesticks at the same time, the system would probably not have predicted or anticipated a high angle of attack that, as previously discussed, was actually never very high.

If the go-around had been initiated earlier, it could have been possible to recover level flight before the hard contact with the runway.

2.4. Weather conditions in Bilbao

The METARs and the information provided by Bilbao TWR only advised of light turbulence. The GPV forecast was for winds of 25 kt, with gusts up to 40 kt, although the crew was probably not aware of those forecasts. With the TWR and METAR information they had received, the crew was only prepared to face winds only from light to moderate, of around 7 to 12 kt, at the airport, although of variable direction around 240°.

The OM of the company limited the advisory to the cases when the winds were from 160° to 230° with intensity higher than 15 kt.

Since the reported winds were lower, and their direction was 240° or 250°, the crew could have had a false sense of confidence about the severity of the turbulence and wind-shear. They could even have thought that the conditions would be better than five hours before, when an aircraft discontinued the approach to Bilbao and deviated to Vitoria. In fact the traffic preceding them landed normally at Bilbao Airport.

Although surface winds were of medium intensity and a WSW direction at the night of the accident, winds at altitude could have been more intense, creating a stronger turbulence than the one expected by the crew.

The circumstances of the accident could suggest a phenomenon known as mountain wave.

This phenomenon usually occurs when strong winds blow perpendicular to a mountain ridge, and is favoured by a stable atmosphere temperature gradient with an increase in wind speed according to height, while, its perpendicular direction to the ridge is maintained.

The information obtained from the CVR indicates that during the approach the aircraft went through a turbulent cumulus (maybe a rotor of a mountain wave) and found 55 kt at 6,000 ft (i.e., stronger at altitude). This could suggest that there were conditions related to mountain wave phenomenon. Data from wind probes in Santander indicate that there may have been good conditions for the development of waving movements in stable layers of the atmosphere.

Since Bilbao airport occasionally suffers from weather conditions with S and SW winds, it seems advisable to thoroughly evaluate the weather phenomena in the Bilbao area, with an aim to increasing knowledge of the development process of turbulent air, gusts, vertical gusts, and wind-shear. Since the risk for aviation of these weather conditions is already present from a certain altitude, it is not enough to provide a METAR with surface conditions. Weather information must be expanded and should cover the whole final approach path.

Winds at surface level are influenced by the circulation of rotors and can be misleading to the crew. It would be advisable in these situations to have anemometers located at mountain crest level, in order to ascertain the wind capability to generate turbulence as a function of its direction.

Even though wind-shear detectors systems are expensive, with the increase in commercial traffic, the advisability of monitoring winds in the Bilbao Airport area could be reconsidered.

2.5. Aircraft evacuation

Some witnesses and the records of injured people suggest that there were scenes of panic and trampling by the crowds.

Of 25 injured, 22 were women and elderly people, probably run over by younger people.

These minor consequences are considered normal in these cases of aircraft emergency evacuations.

The convenient position of the SEI service, close to the area where the aircraft came to rest and their immediate intervention precluded a possible fire and a more difficult evacuation.

2.6. Line flying under supervision

On this flight there seemed to be no restrictions for any crew member to exercise the privileges granted by their licenses. The operator reported that the captain had complied with the requirements to act as a supervisor and the pilot flying (PF) was in the line-flying-under-supervision phase of his training program. He had a license with no restrictions to fly under supervision, and therefore he was authorized to land the aircraft.

It is worth noting that the regulation in force at the time of the accident imposed certain temporary landing restrictions, under normal conditions, for pilots in command under supervision but not applicable for co-pilots under supervision. Moreover in this case in which the weather conditions were adverse, it is deemed that some convenient operational restrictions should have been in place to avoid a pilot under supervision being at the controls during the landing. The operator's recommendation not to operate at Bilbao Airport under certain weather conditions, mentioned in paragraph 1.17.1 above, should be more restrictive for co-pilots and other crew members under instruction.

Taking into account that the JAR-OPS 1 regulations require that the OM addresses several aspects of the flights under supervision, subject to authority approval, two safety recommendations are issued, one of them to the operator and the other to the DGAC of Spain, to adequately restrict the functions and privileges of pilots in line flying under supervision. These restrictions should be applicable to routes and airports known to develop special operational conditions under certain meteorological situations which usually lead to a high percentage of non-stabilized approaches and go-arounds. On the other hand, the Aeronautical Authority (DGAC) should consider the proposed requirements and restrictions before approving operations manuals.

3. CONCLUSION

3.1. Findings

— During the approach to Bilbao Airport the aircraft experienced signs of moderate to severe turbulence.
— High altitude wind intensities and other weather conditions were conducive to the appearance of turbulence phenomena.
— The aircraft's vertical speed in the last seconds of the approach was very high.
— The design of the flight control system was such that the actions of both pilots over the flight controls were ignored by the logic of the control system and prevented the aircraft from flaring.
— TOGA thrust was applied to the engines in the last instant before touchdown but the aircraft could not initiate a climb.
— The aircraft impacted with the nose gear, centred on the runway, at the threshold. The nose gear collapsed and the aircraft stopped after 1100 m of ground run. At the end of the run, the aircraft lost directional control and came to a stop at an angle to the runway.
— The aircraft suffered damage to the nose gear and the two engine nacelles, and the main gear tires burst. Internal stuctural damage caused the aircraft to be written off.

3.2. Causes

The cause of the accident was the activation of the angle of attack protection system which, under a particular combination of vertical gusts and windshear and the simultaneous actions of both crew members on the sidesticks, not considered in the design, prevented the aeroplane from pitching up and flaring during the landing.

4. SAFETY RECOMMENDATIONS

As previously stated in this report (see paragraph 1.18.1), the following preliminary safety recommendation was issued on 12 March 2001 addressed to the French Civil Aviation Authorities (DGAC-F): «To define with the manufacturer and to immediately issue, safety measures to prevent the repetition of these kind of events in aircraft of the A-320 family and in other aircraft equipped with similar flight control systems».

The modifications on the ELAC software developed by the manufacturer and fully retrofitted to the fleet by the end of 2002, are described in paragraph **1.18.3 - Corrective actions by Airbus.** These modifications are considered as actions taken in response to this safety recommendation.

Additionally, the following recommendations are issued.

REC 20/06. Considering that Bilbao Airport occasionally suffers from certain weather conditions with winds from the south and southwest, it is recommended that the INM conduct thorough research on meteorological phenomena within the area of Bilbao, aimed at improving our knowledge of the development of turbulence, gusts and windshear in the vicinity of the airport, and to use this information to improve operations during the approach phase.

REC 21/06. Taking into account that the dual input actions on the sidestick cause the effect of adding both inputs, it is recommended that the operator Iberia improve the instruction of their A-320 crews in order to avoid the simultaneous activation of the sidestick by both pilots without pushing the «override button», regardless of the type and composition of the flight crew.

REC 22/06. Considering that the confluence of marginal weather conditions and the circumstances of «line flying under supervision» can configure operation scenarios of increased risk, it is recommended that Iberia establish adequate restrictions in its Operation Manual as regards crew members in «line flying under supervision», taking into account the different phases of flight and the characteristics of the airports of operation.

REC 23/06. Taking into account the preceding safety recommendation (22/06), it is recommended that the Aeronautical Authority (DGAC) consider as a valid criteria for the approval of commercial air transport operators the inclusion in their Operation Manuals of adequate restrictions applicable to crew members in «line flying under supervision».

APPENDICES

APPENDIX A
DFDR data

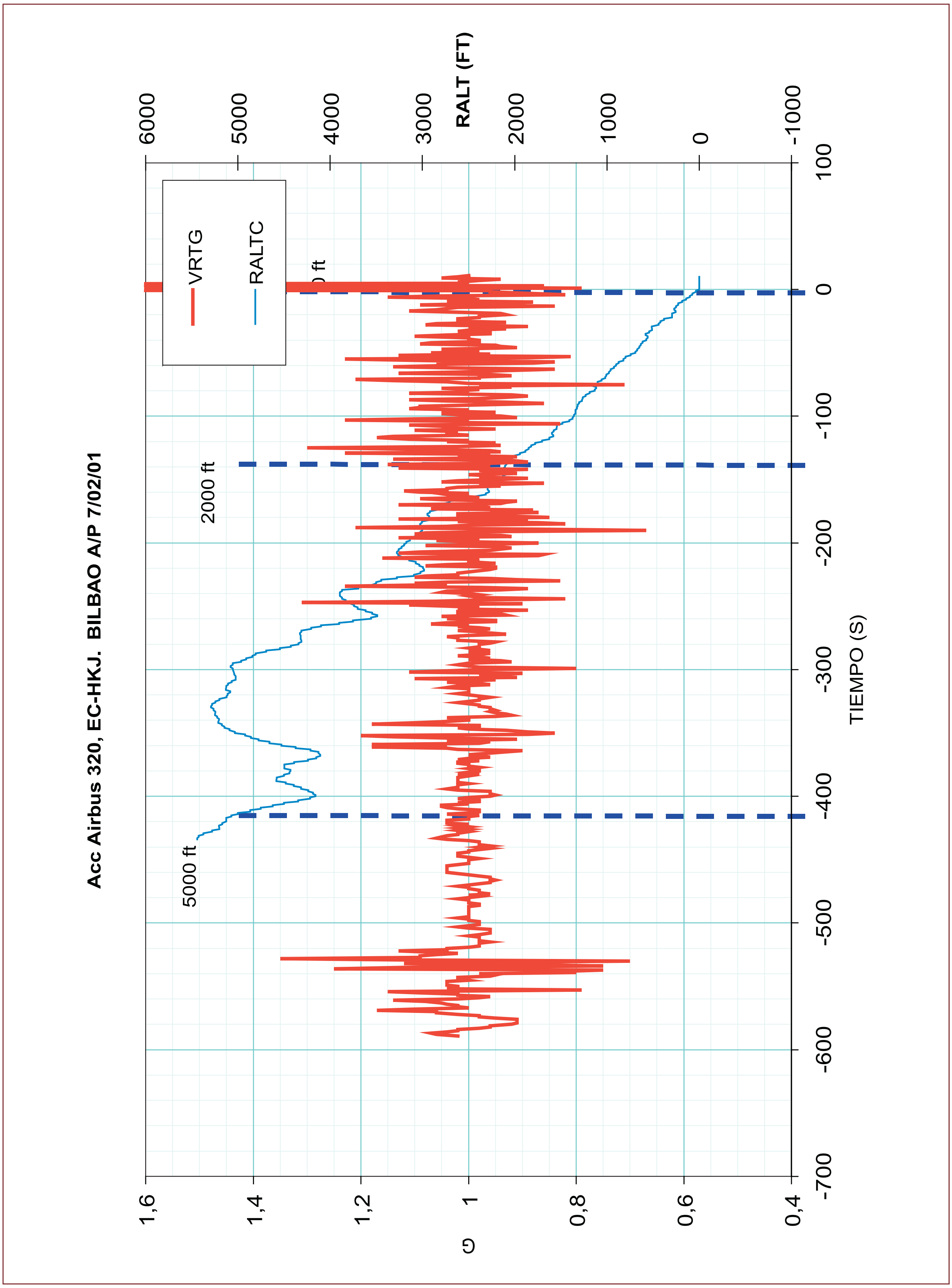


Figure 1. *Vertical acceleration records*

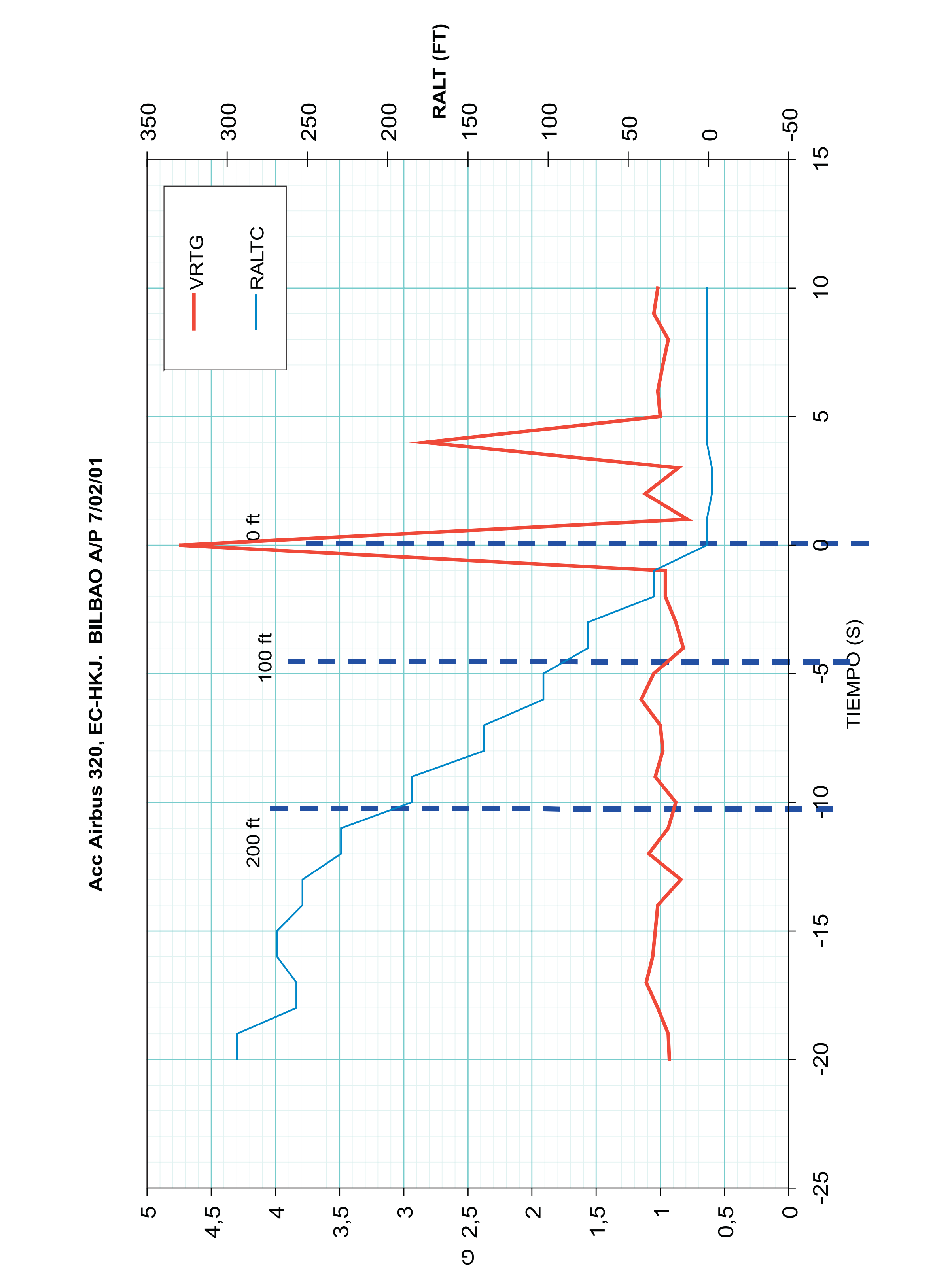


Figure 2. *Vertical acceleration records (continued)*

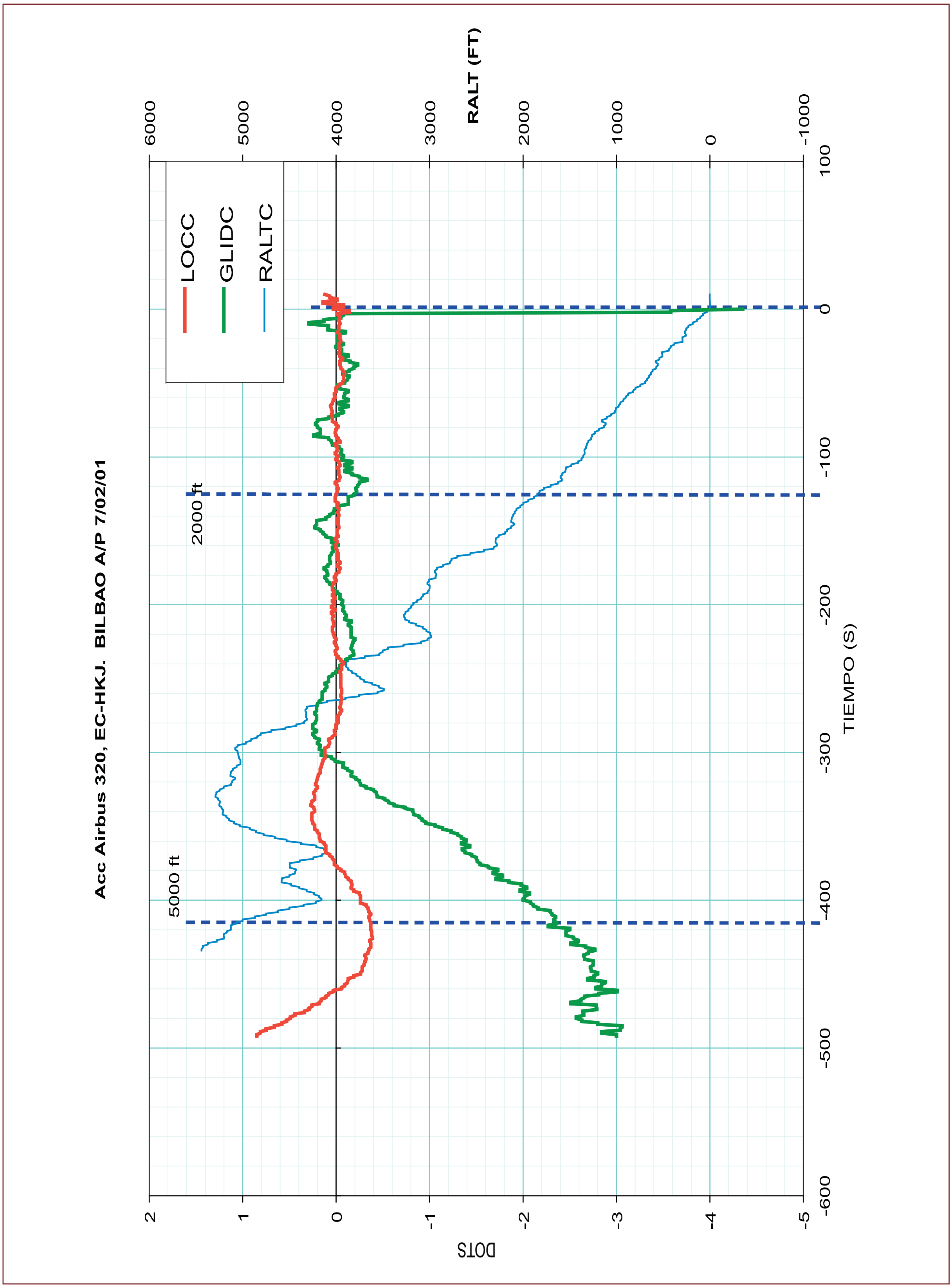


Figure 3. *ILS deviations*

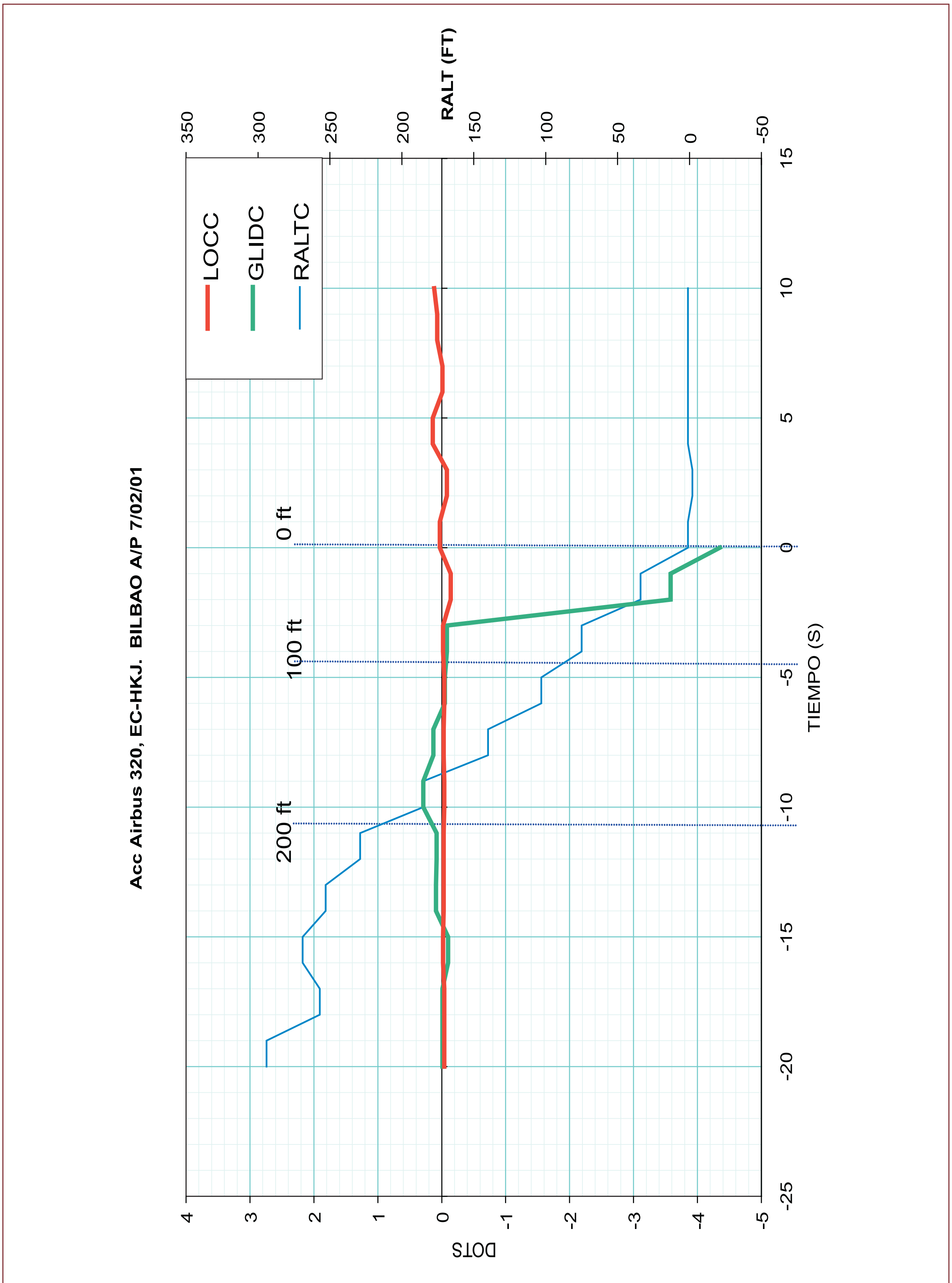


Figura 4. *ILS deviations (continued)*

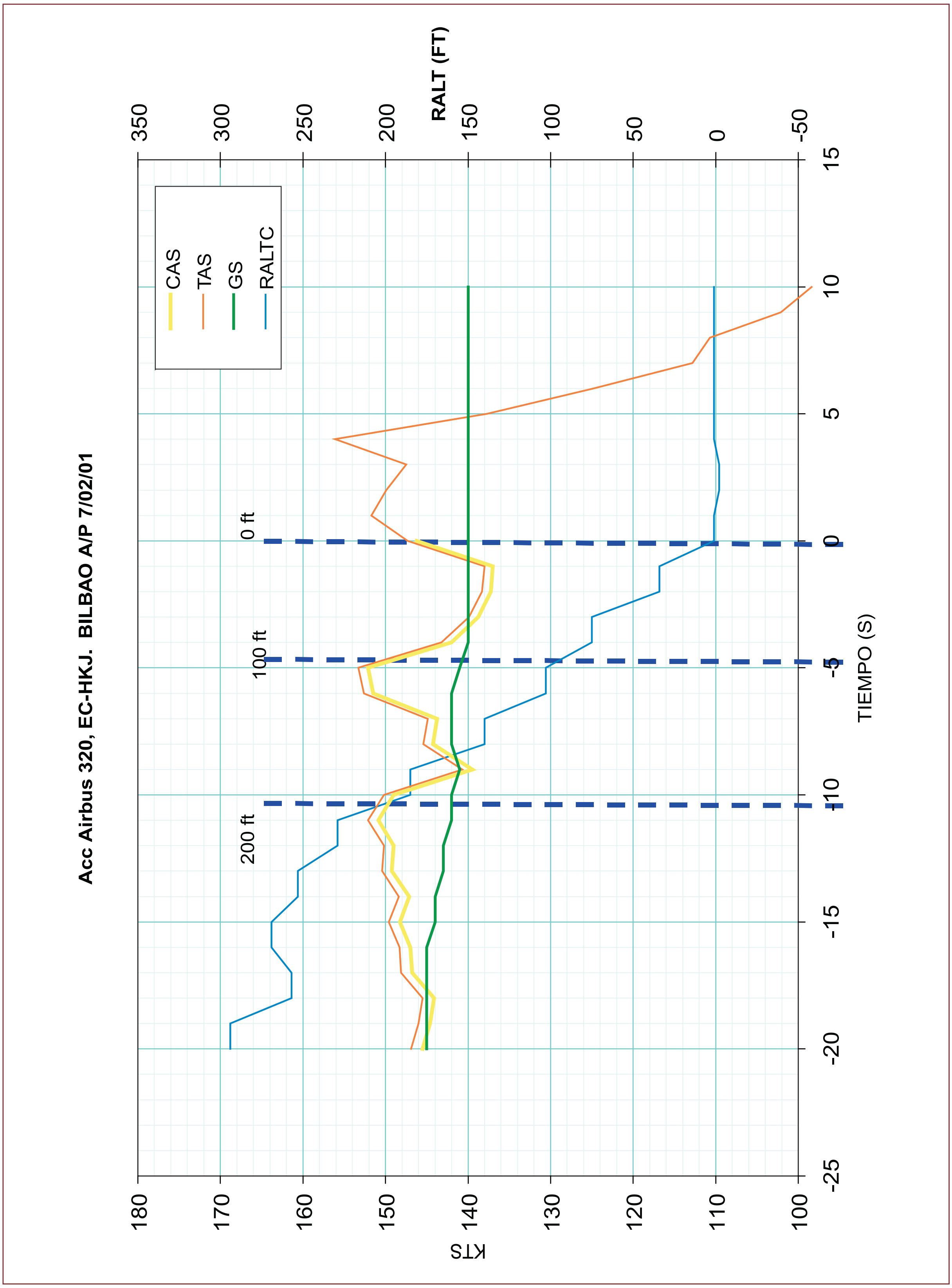


Figure 5. *Speed records*

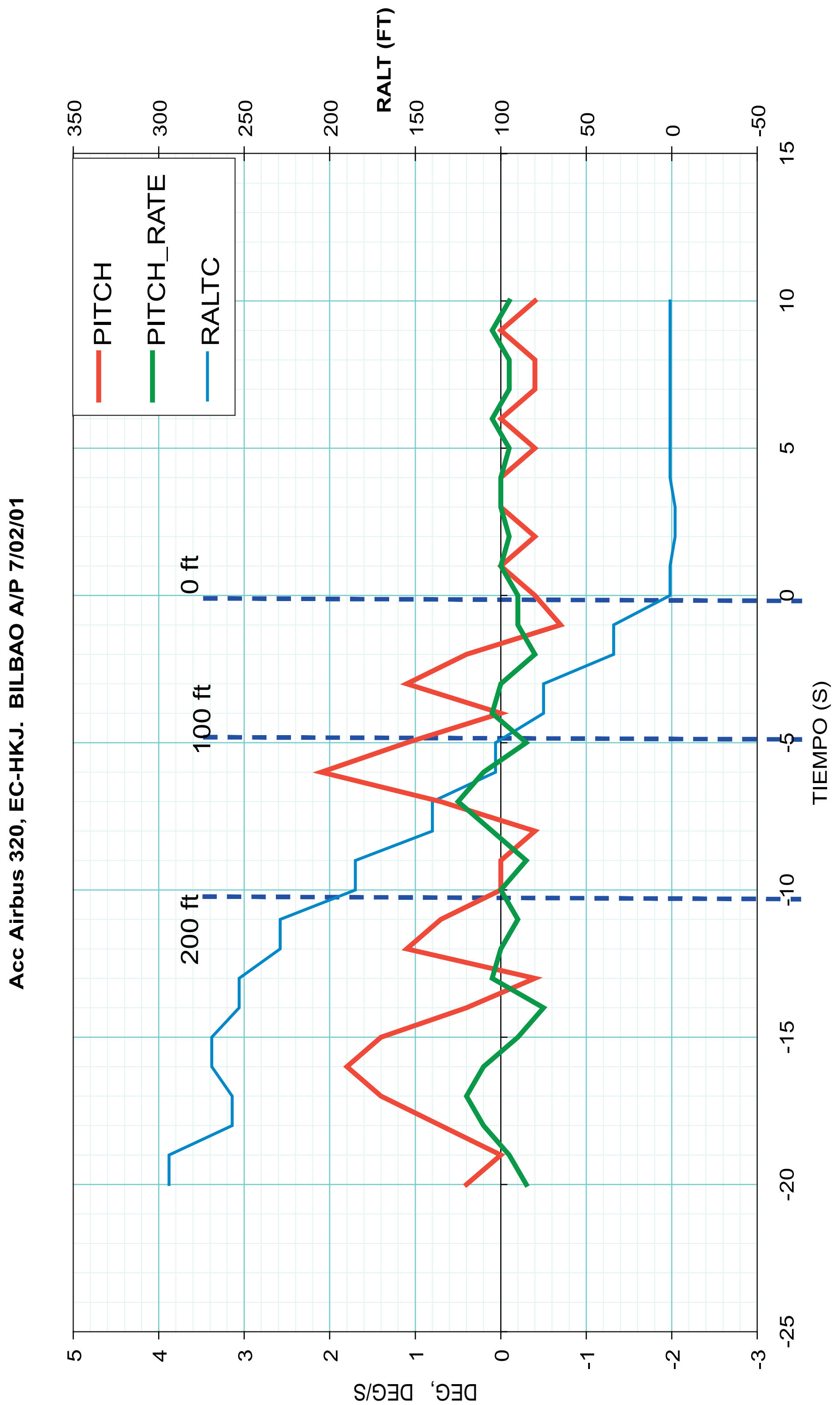


Figure 6. *Pitch angle and pitch angle rate*

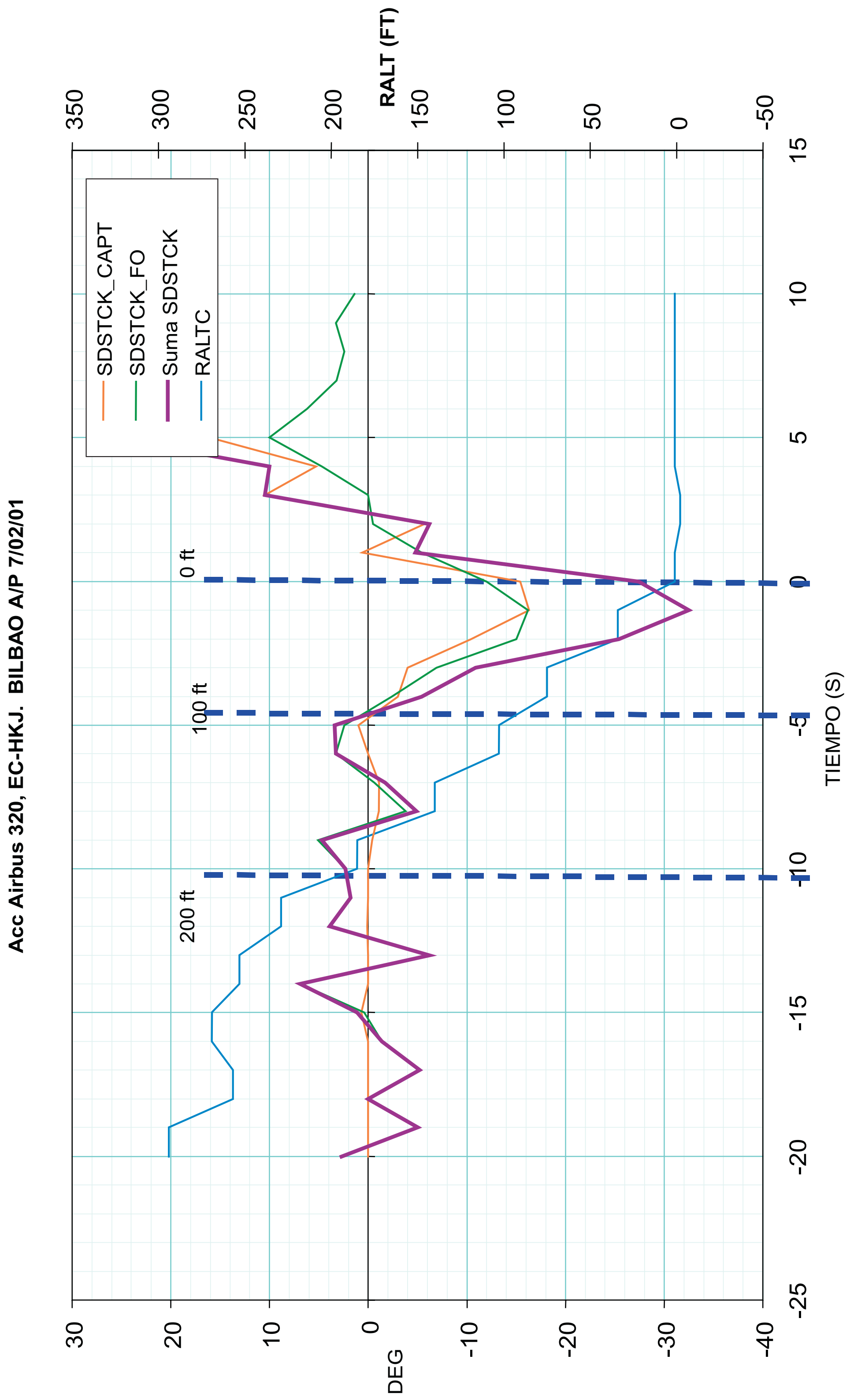


Figure 7. *Actions of the pilots on the sidesticks*

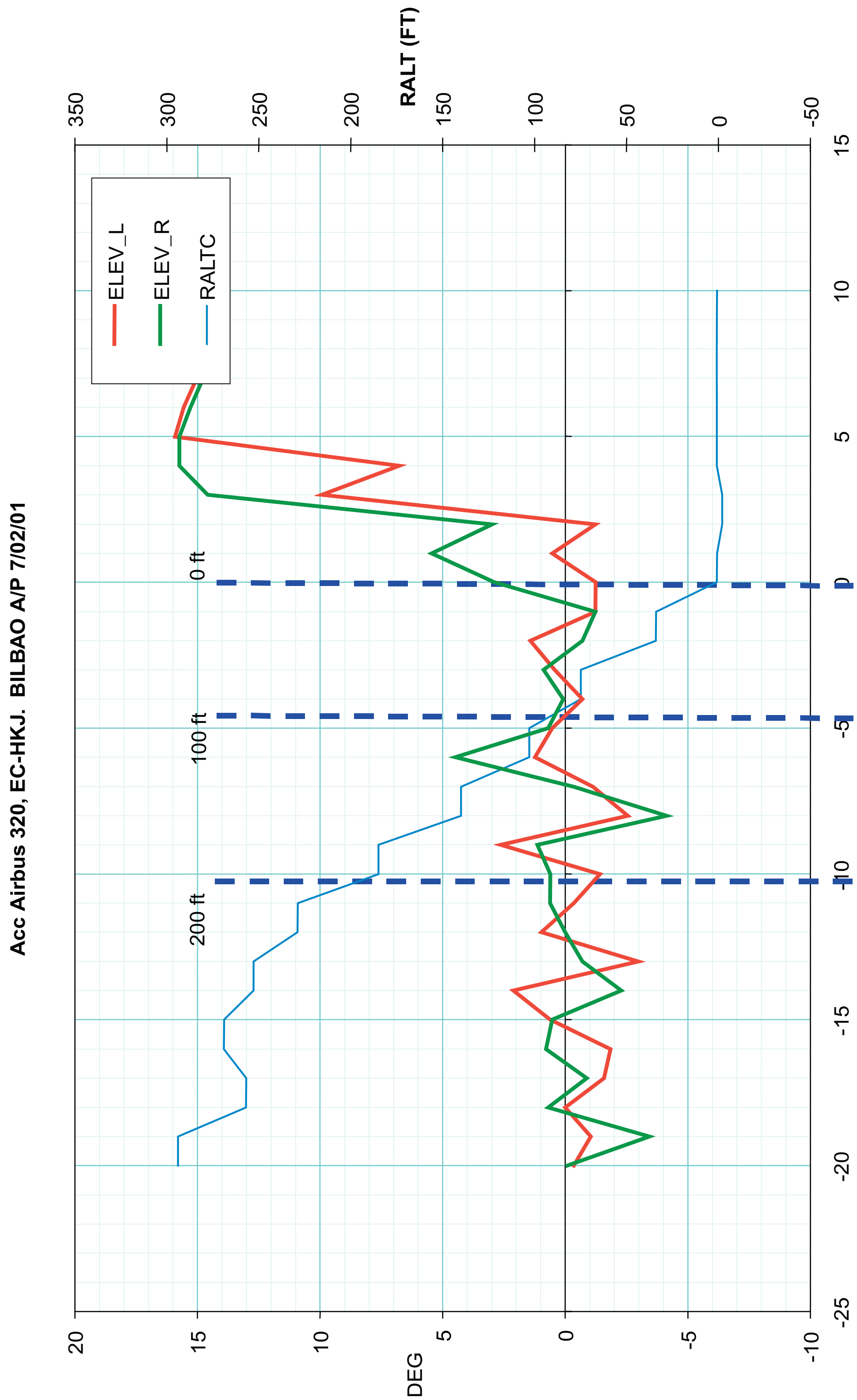


Figure 8. *Angles of deflection of the elevators*

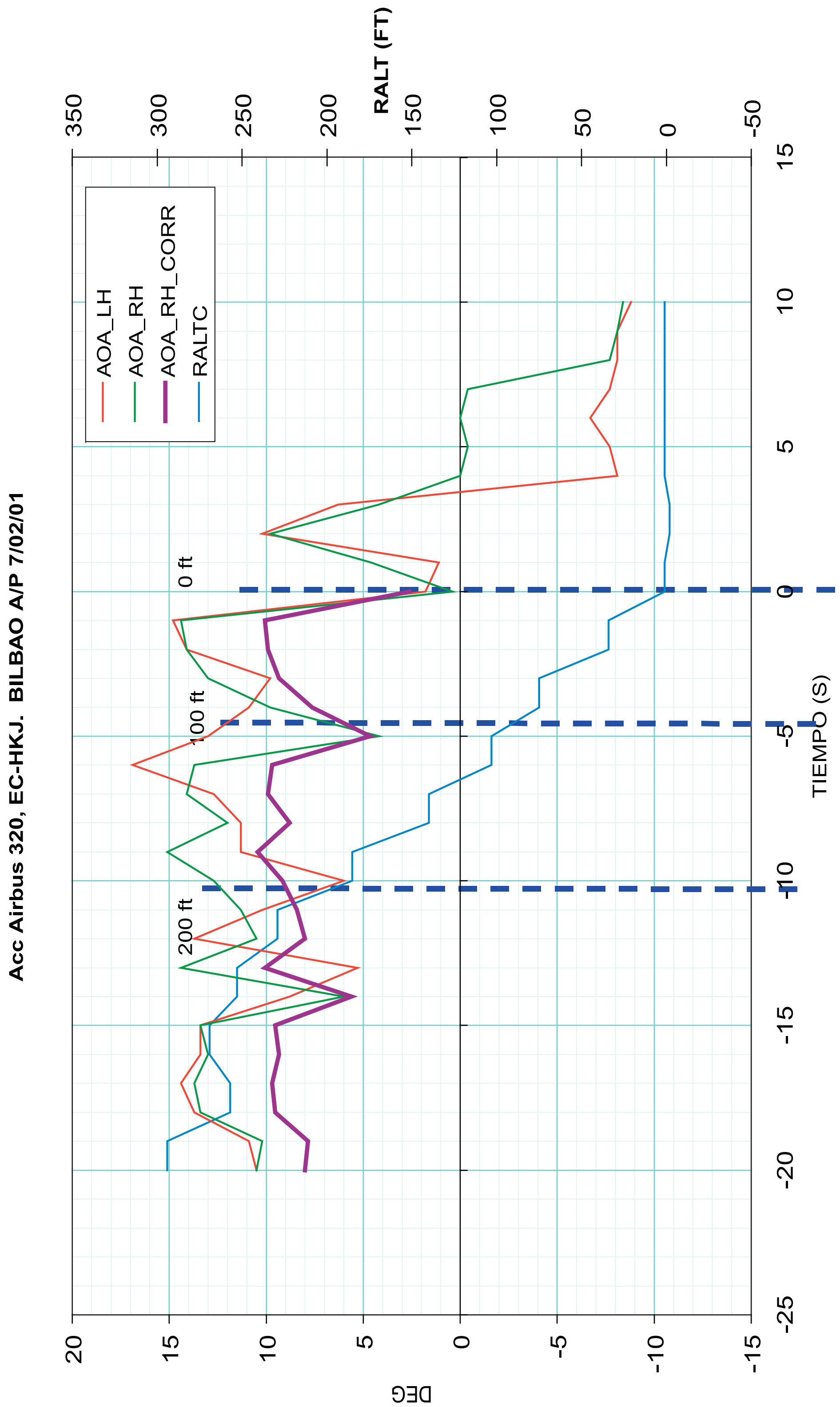


Figure 9. *Angle of attack records and estimate of the corrected angle of attack*

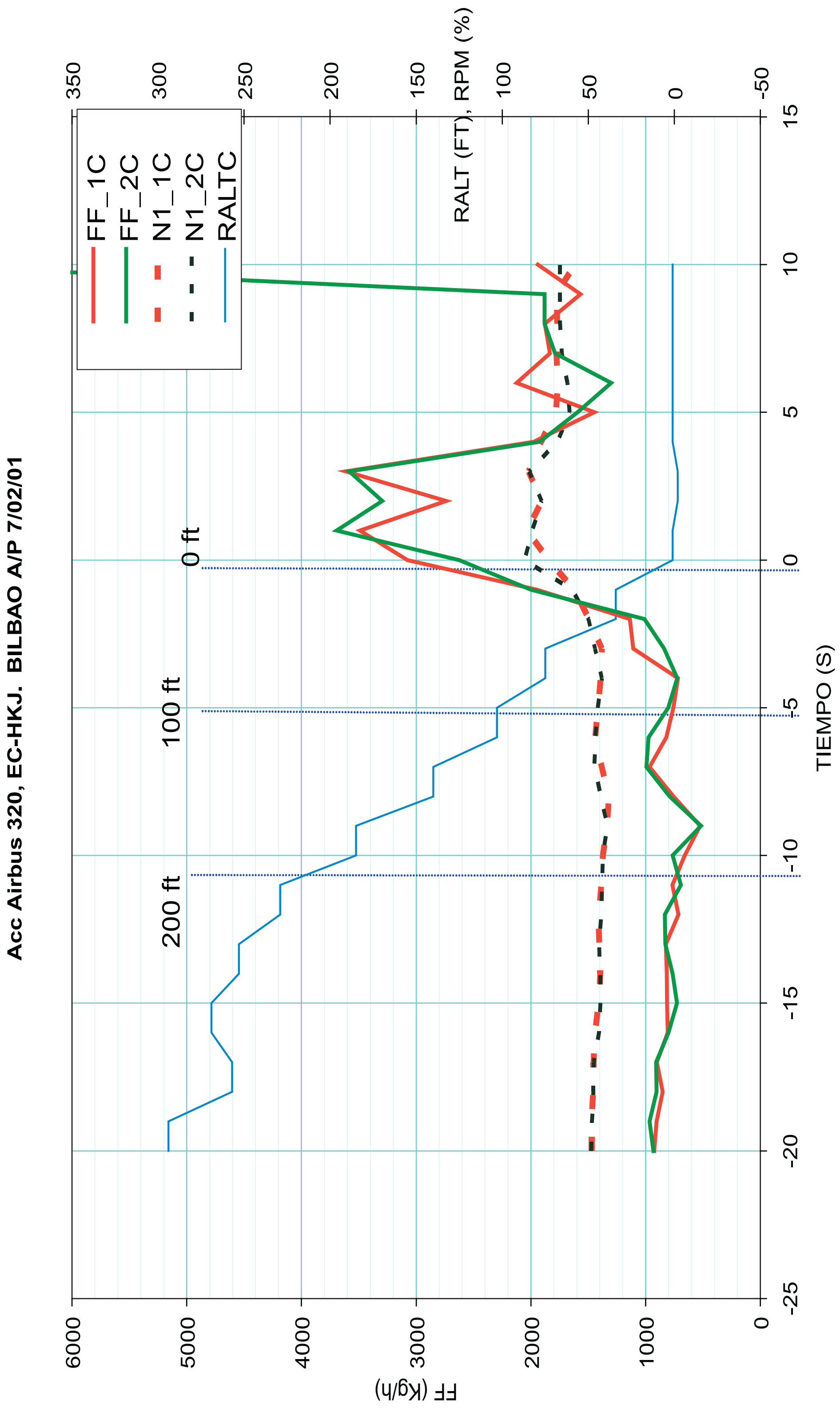


Figure 10. *Engine parameters*

APPENDIX B
Maps and charts of Bilbao Airport

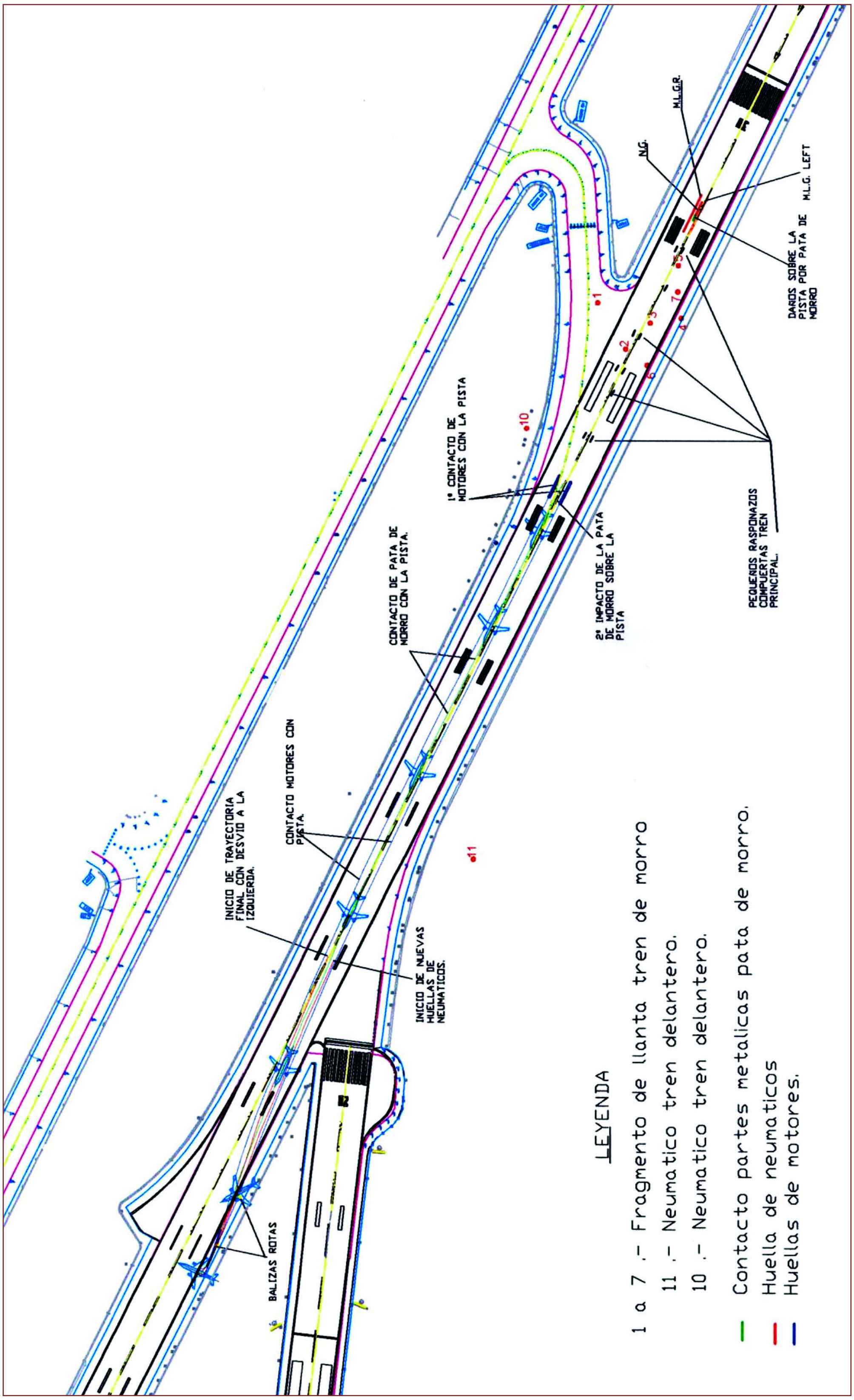


Figure 1. *Drawing of Bilbao runway 32, runway marks and wreckage distribution*

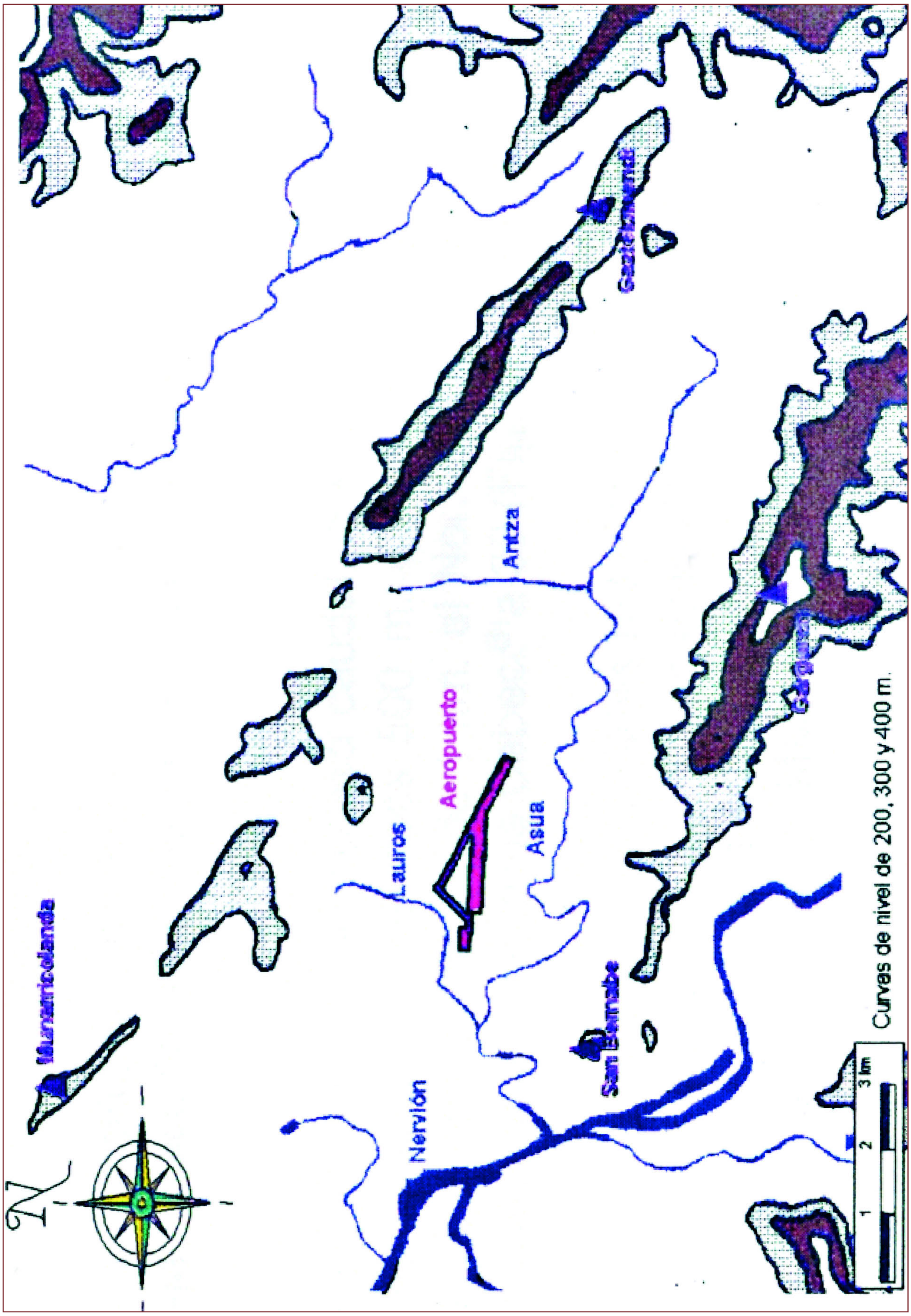


Figure 2. *Drawing of the mountain area around Bilbao Airport*

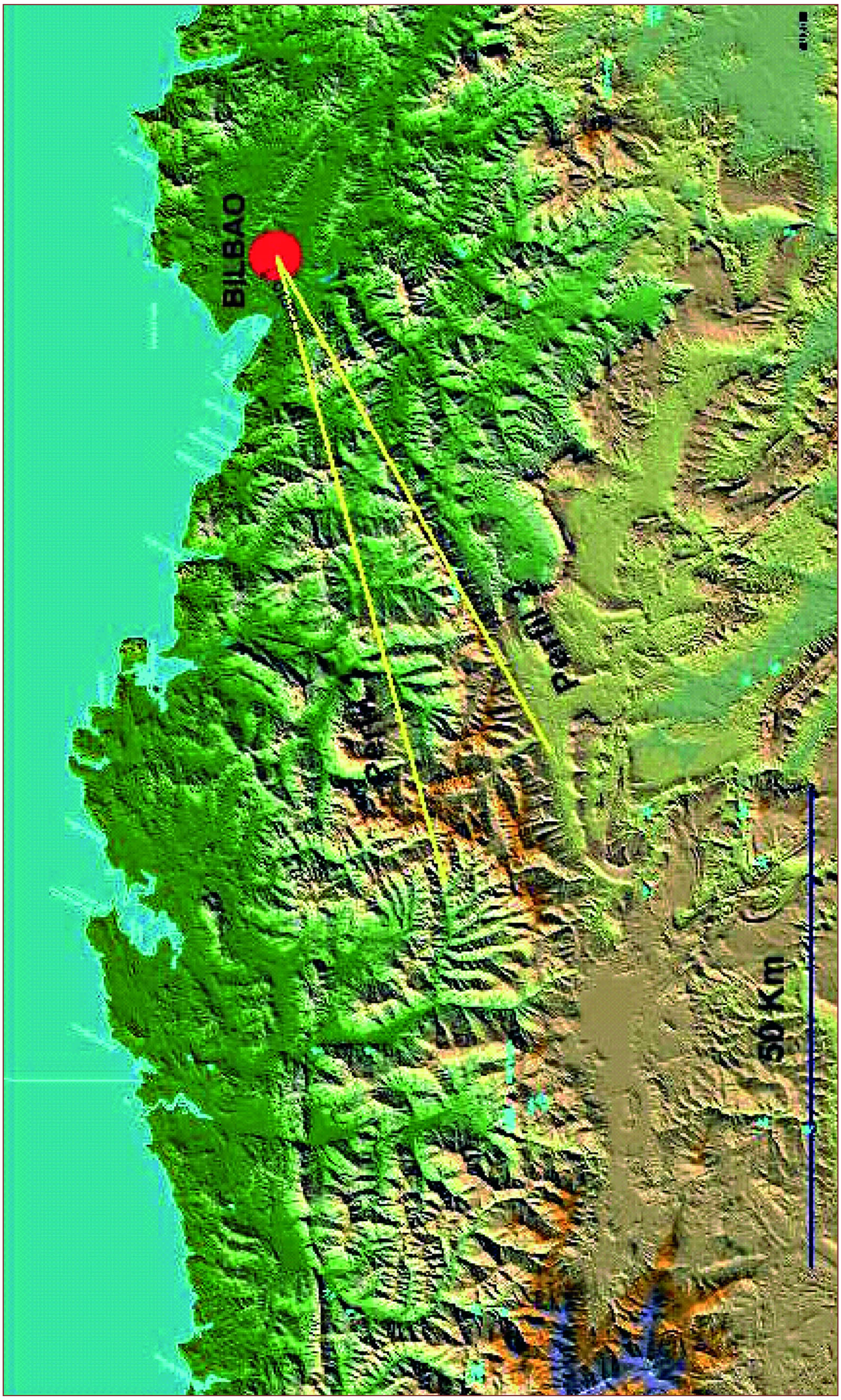


Figure 3. *Orographic map showing the mountain ridges to the SW of Bilbao*

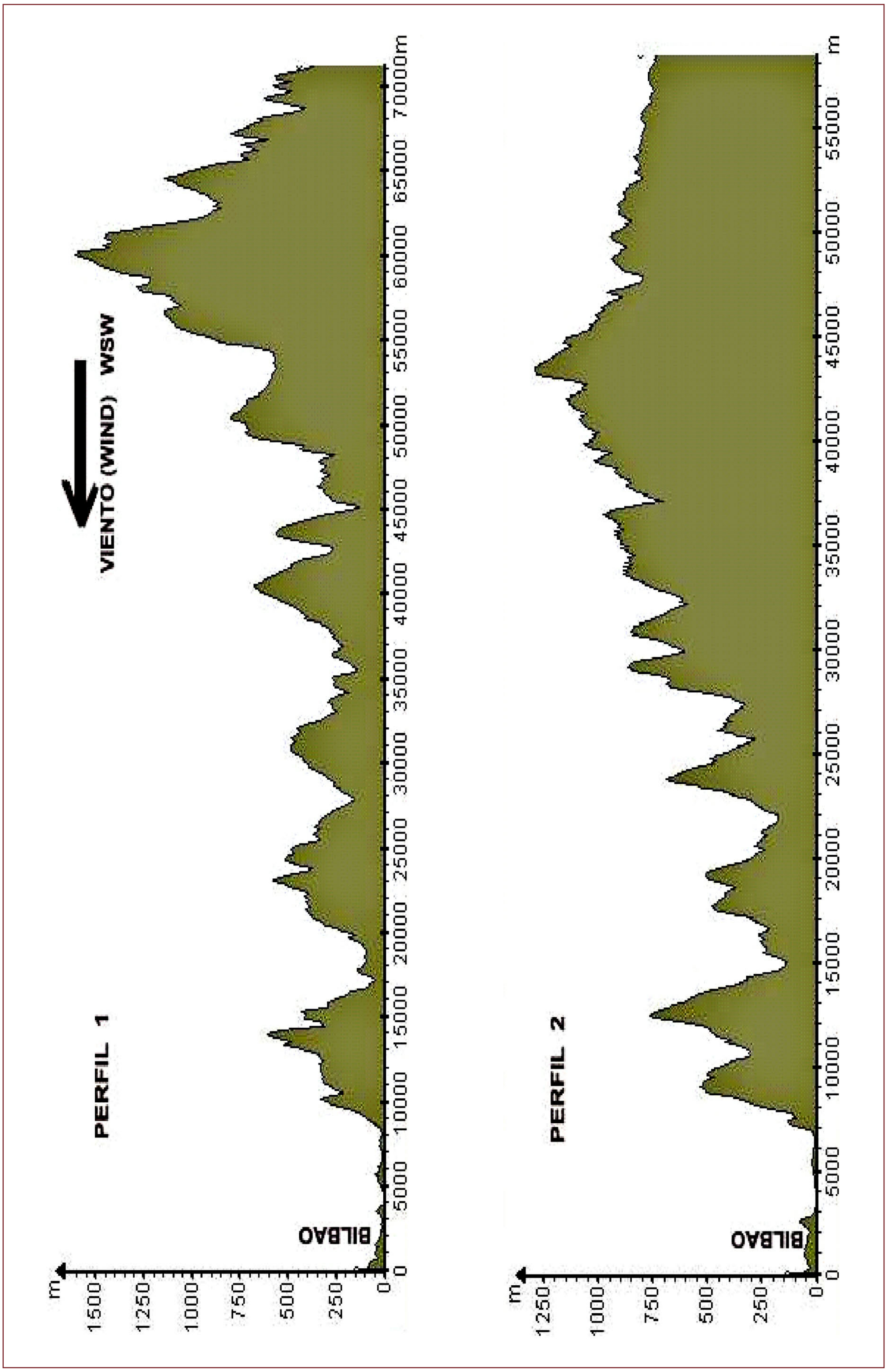


Figure 4. *Orographic profiles of the mountains in the directions shown in Figure 3*