INISTERE DES TRANSPORTS, DE L'EQUIPEMENT, DU TOURISME ET DE LA MER – BUREAU D'ENQUETES ET D'ANALYSES POUR LA SECURITE DE L'AVIATION

BEA

Accident on 22 June 2003 at Guipavas (21) to the Bombardier Canadair CL-600 2B 19 registered F-GRJS operated by Brit Air

REPORT TRANSLATION

f-js030622a

F O R E W O R D

This report presents the technical conclusions reached by the BEA on the circumstances and causes of this accident.

In accordance with Annex 13 of the Convention on International Civil Aviation, European Directive 94/56/CE and French Law n° 99-243 of 29 March 1999, the conclusions contained in this report are intended neither to apportion blame, nor to assess individual or collective responsibility. The sole objective is to draw lessons from this occurrence which may help to prevent future accidents or incidents.

Consequently, the use of this report for any purpose other than for the prevention of future accidents could lead to erroneous interpretations.

SPECIAL FOREWORD TO ENGLISH EDITION

This report has been translated and published by the BEA to make its reading easier for English-speaking people. As accurate as the translation may be, the original text in French should be considered as the work of reference.

Table of contents

Glossary

AAL	Above Airfield Level
AGL	Above Ground Level
AIP	Aeronautical Information Publication
ATIS	Automatic Terminal Information Service
Cat	Category
CFIT	Controlled Flight into Terrain
CODIS	Regional fire-fighting and rescue centre (Centre opérationnel départemental d'incendie et de secours)
CVR	Cockpit Voice Recorder
DGAC	General Directorate for Civil Aviation (Direction Générale de l'Aviation Civile)
DME	Distance Measuring Equipment
EASA	European Aviation Safety Agency
EGPWS	Extended Ground Proximity Warning System
FD	Flight Director
FDR	Flight Data Recorder
FIR	Flight Information Region
FMR	Flight Mode Annunciator
ft	feet
GPWS	Ground Proximity Warning System
HGS	Head-up Guidance System
HIS	Horizontal Situation Indicator
IAF	Initial Approach Fix
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IRMA	Aircraft movement indicator radar
KHz	Kilohertz
Kt	Knot (s)
LOC	Localizer
LVP	Low Visibility Procedure
MDA	Minimum Descent Altitude
MHz	Megahertz
MSAW	Minimum Safe Altitude Warning
NM	Nautical mile
NOTAM	Notice to Airmen
OM	Outer Marker
PF	Pilot in Function
PFD	Primary Flight Display
PNF	Pilot Not in Function

QNH	Altimeter setting to obtain airfield elevation when on the ground
RCA	Air traffic regulation
RVR	Runway Visual Range
SASV	Flight safety analysis department
SFI	Simulator Flight Instructor
STNA	Air traffic technical service (Service Technique de la Navigation Aérienne)
TEMSI	Significant weather chart
TOGA	Take Off Go Around
UTC	Universal Time Coordinated
VOR	VHF Omnidirectional Radio Range

SYNOPSIS

Date and time
22 June 2003 at 21 h 51 (1)

Site of accident
Guipavas (29) (France)

Type of flight
Public transport of passengers
Scheduled flight AF 5672
Nantes – Brest

Aeroplane
Bombardier Canadair
CL-600 2 B 19 "CRJ-100"
Registered F-GRJS

Owner
Armor Lease

Operator
Brit Air

Persons on board
2 Flight Crew
1 Cabin Crew
21 passengers

Summary

On an ILS approach to runway 26 Left at Brest Guipavas aerodrome, the aeroplane deviated progressively to the left of the normal runway approach track. It passed above and then below the glide path and descended until it touched the ground 2,150 meters from the runway threshold, 450 meters from the extended runway centreline. The aeroplane struck several obstacles and caught fire.

Consequences:

	Persons			Equipment	3rd parties
	Killed	Injured	Unhurt		
Crew	1	1	1	Destroyed	-
Passengers	-	4 *	17		

* including three seriously

(1) Except where otherwise noted, the times shown in this report are expressed in Universal Time Coordinated (UTC). Two hours should be added to obtain the legal time applicable in metropolitan France on the day of the accident.

ORGANIZATION OF THE INVESTIGATION

The BEA duty officer was informed of the accident on 23 June at around 00 h 50, Paris time, about one hour after the accident. In accordance with Annex 13 of the Convention on International Civil Aviation and the French Civil Aviation Code (Book VII), a safety investigation was launched and an Investigator-in-Charge (IIC) nominated. The safety investigator in charge of the BEA Rennes regional office and the Field Investigator began work at the accident site on the Monday morning, and were joined in the afternoon by eight other investigators, including the IIC. All of the work undertaken was done in coordination with those responsible for the judicial investigation.

The aeroplane being of Canadian construction, the BEA invited its Canadian counterpart, the Transportation Safety Board, to nominate an Accredited Representative, in accordance with international agreements. The latter joined the IIC on 24 June, assisted by three advisers from Bombardier and one adviser from Transport Canada. A local representative from Bombardier had already joined the investigation, with the agreement of the Canadian Accredited Representative. Since the engines were of American manufacture (General Electric), the National Transportation Safety Board, the American investigative body, was kept informed. In the light of the information available, it was decided that its representatives need not travel to the site.

To conduct the safety investigation, the IIC was assisted by a group of nine investigators, two technical assistants as well as by an airline pilot and an Air Traffic Control specialist who are experts associated with the BEA. A Captain who is a specialist in flight safety was also made available to the BEA by Brit Air.

Six working groups were constituted so as to find and gather the information required for the investigation in the following areas:

- site, wreckage, survival factors, safety;
- testimony, radar data, radio communications, ATC, meteorology, infrastructure;
- flight recorders;
- medical aspects;
- ILS calibration, aeroplane, crew, maintenance;
- preparation and conduct of flight, operation and performance.

Bombardier provided various calculations and simulations upon request during the investigation.

A Preliminary Report was published on 31 July 2003.

1 - BASIC INFORMATION

1.1 History of Flight

On Sunday 22 June 2003, the CRJ-100 registered F-GRJS was operating as scheduled flight AF 5672 between Nantes Atlantique and Brest Guipavas aerodromes (France) under an IFR flight plan. The flight represented the last leg of a Brest – Nantes – Strasbourg – Nantes – Brest rotation. The aeroplane was operated by Brit Air on behalf of Air France. The Captain was pilot flying (PF). The crew also included another pilot (the co-pilot), and one cabin crew.

The aeroplane took off at 21 h 16 [(2)] with twenty-one passengers. The flight was approximately fifty minutes late, due to a delay in the first flight of the day that had affected the subsequent flights.

During the flight, with the authorisation of the control centre, the crew passed northeast of the planned track in order to avoid cumulonimbus formations. At Brest Guipavas, the 21 h 00 ATIS indicated visibility of eight hundred meters with some fog and a cloud base at two hundred feet with the presence of cumulonimbus. The runway in use was 26 Left with an ILS approach. Runway use was temporarily restricted to Cat I due to presence of works.

At 21 h 36 min 27 s, the flight (radio call sign BZ 672 EC) was cleared by the en-route controller to descend to Flight Level 150 then, at 21 h 39 min 10 s, to Flight Level 70.

At 21 h 39 min 23 s, the crew announced that they were descending to Flight Level 70 towards BODIL, the initial approach fix, avoiding storms.

At 21 h 39 min 31 s, the Brest approach controller transmitted "Descend four thousand feet QNH one thousand and eight, number two on approach, plan a holding pattern at Golf Uniform".

At 21 h 44 min 21 s, the controller cleared descent to three thousand feet and added "and perform a holding pattern". The aeroplane was approximately 20 NM DME from BG.

At 21 h 47 min 40 s, that is, approximately one-and-a-half-minutes before the planned start of the hold, the controller cleared descent to two thousand feet QNH.

At 21 h 48 min 01 s, the controller announced "Echo Charlie, preceding aeroplane has landed, continue the approach, report at Outer Marker". Four seconds later, at 9.4 NM DME, the autopilot "Heading" and "Vertical Speed" modes became active and the aeroplane adopted a heading of 257°. The Brest ILS frequency was displayed on the VOR 1 and the VOR navigation source was selected.

[(2)] This time was recalculated from the onboard recordings.

At 21 h 48 min 21 s, the controller called back "Are you ready for the approach?". The crew confirmed and the controller asked "Report at Outer Marker". The Copilot read this back.

At the Captain's request, the Co-pilot extended the flaps to 20° then the landing gear. The aeroplane stabilized at two thousand feet QNH on autopilot, still in Heading mode, at about 7 NM DME. Simultaneously, the wind, which had started to veer northwest during the descent, caused the aeroplane to drift towards the left. The flight crew did not notice this drift.

At 21 h 49 min, the co-pilot extended the flaps to 30° then to 45° and the crew performed the pre-landing checklist.

At 21 h 49 min 35 s, the controller cleared the landing for runway 26 Left and indicated a cloud base of less than one hundred feet.

At 21 h 49 min 40 s, the aeroplane, in level flight, passed under then above the glide slope.

At 21 h 50 min, the aeroplane passed the GU beacon, slightly to the left, with a track deviating to the left in relation to the localizer centreline. At that moment, the wind calculated by the Flight Management System (FMS) was 300° / 20 kt. A short time later, the aeroplane began its descent. The aeroplane continued to drift to the left of the localizer centreline.

At 21 h 50 min 45 s the aeroplane again passed through the glide slope, and the Captain said "Approach selected, LOC and Glide"; the Co-pilot confirmed. The autopilot "heading" and "vertical speed" modes remained active. The aeroplane thereafter remained below the glide slope for the remainder of the flight.

Between 21 h 50 min 58 s and 21 h 51 min 02 s, the GPWS announced, successively, "Five hundred", "Glide slope" then "Sink rate".

At 21 h 51 min 01 s, the aeroplane began a turn to the right. By this time, the aeroplane was 4.68 points to the left of the localizer centreline.

At 21 h 51 min 04 s, the Captain disengaged the autopilot.

At 21 h 51 min 05 s, the GPWS announced "Three hundred".

Between 21 h 51 min 07 s and 21 h 51 min 14 s, seven "Glide slope" alarms sounded. During this time, the Co-pilot said "come right" on two occasions and the aeroplane attitude changed from - 5° to 0°.

At 21 h 51 min 15 s, the GPWS announced "One hundred".

At 21 h 51 min 16 s, with the aeroplane at 529 feet QNH and 93 feet on the radio-altimeter, the Co-pilot said "I've got nothing in front", then the Captain said "Go around". Simultaneously, the engine thrust increased significantly. The aeroplane attitude returned to - 5 in four seconds.

At 21 h 51 min 19 s, the Co-pilot said "Go around".

At 21 h 51 min 20 s, the GPWS announced "Sink rate" then "Pull up".
The Co-pilot said "Go around" again at 21 h 51 min 22.

The first sounds of the impact were recorded by the CVR at 21 h 51 min 22 s, and the recording stopped at 21 h 51 min 24. s.

The aeroplane, which touched the ground without any great force, rolled, struck several obstacles and ended up 450 meters left of the extended runway centreline, 2,150 meters from the runway threshold.

The Captain was killed. The rest of the crew and the passengers managed to evacuate the aeroplane, which was destroyed by fire.

1.2 Killed and Injured

Injuries	Crew members	Passengers	Others
Fatal	1	-	-
Serious	1	3	-
Light/None	1	18	-

The co-pilot and three passengers remained hospitalized for more than forty-eight hours.[3] Five other passengers were hospitalized for less than forty-eight hours, one for an injured left collarbone.

1.3 Damage to Aircraft

The aeroplane was destroyed by the successive impacts and the fire.

1.4 Other damage

Two concrete electrical power poles and two pine telephone poles were destroyed. In addition, a field, an embankment, a mown field, a stone wall, some trees and the surface of a road were damaged.

[3] The forty-eight hour threshold was applied in accordance with the definition of a "serious injury" as defined in the Civil Aviation Code (Book VII). The collarbone injury is not considered as a "serious injury".

1.5 Personnel information

1.5.1 Flight crew

1.5.1.1 Captain

Male, aged 53.

Aeronautical qualifications:

- Commercial pilot's license issued 1976.
- Instrument Rating issued July 1980.
- Professional helicopter pilot's license issued 1984.
- Commercial pilot's license issued June 1990 by Canada.
- Commercial pilot's license No. 524294 issued 3 February 1994 by France.
- CRJ-100 type rating issued on 21 May 1995, extended on 20 August 2002.
- Cat IIIa precision approach rating dated 11 January 2003.
- Last line check on 13 September 2002, on CRJ-700[4].
- Last base check on 11 January 2003.
- Last medical certificate obtained on 11 April 2003, valid until 31 October 2003.

Professional experience:

- 16,000 flying hours of which 5,300 on type.
- 96 hours and 45 minutes in the three previous months, all on type.
- 46 hours and 37 minutes in the previous month, all on type.
- 3 hours and 32 minutes in the previous 24 hours, all on type [(5)].

Work schedule in June:

1st to 11 June: vacation.
12 au 16 June: flight.
17 au 18 June: rest period.
19 June: flight.
20 June: rest period.

Rotations performed on the day before and on the day of the event:

On 21 June:

Flight No.	Departure	Destination	Departure	Arrival	Aeroplane
AF 5671	Brest	Nantes	3 h 56	4 h 35	CRJ-100
AF 5771	Nantes	Strasbourg	5 h 08	6 h 22	CRJ-100
AF 5770	Strasbourg	Nantes	7 h 50	8 h 23	CRJ-100
AF 5670	Nantes	Brest	9 h 00	9 h 38	CRJ-700

(4) The CRJ 100 and 700 have a common qualification (see § 1.17.2.1.3).
(5) The flight time of the accident flight was included in the Preliminary Report.

On 22 June:

Flight No.	Departure	Destination	Departure	Arrival	Role	Aeroplane
AF 5673	Brest	Nantes	16 h 20	17 h 03	PNF	CRJ-700
AF 5773	Nantes	Strasbourg	17 h 33	19 h 00	PNF	CRJ-100
AF 5772	Strasbourg	Nantes	19 h 25	20 h 47	PF	CRJ-100
AF 5672	Nantes	Brest	21 h 05	-	PF	CRJ-100

Notes:

- These times are the block times noted by the crew during their stopovers;
- The rotation for the day of the accident was planned for a CRJ-100; a scheduling change meant that the first leg was performed with a CRJ-700; the crew were informed of the change upon arrival at the airport to commence their flight preparations;
- The CRJ-700 arrived late at Brest due to a technical problem on the brake system, which delayed operations by about fifty minutes.

1.5.1.2 Co-pilot

Male, aged 38.

Aeronautical qualifications:

- Commercial pilot's license No. 1929699, issued 5 May 1999.
- Instrument Rating issued 1 July 2000.
- CRJ-100 type rating issued 29 April 2001, extended on 20 May 2003.
- Instructor on Synthetic Flight Instructor (SFI) since 6 April 2001.
- Cat IIIa precision approach rating dated 20 May 2003.
- Last line check on 16 December 2002.
- Last base check on 20 May 2003.
- Last medical certificate obtained on 25 March 2003, valid until 30 March 2004.

Professional experience:

- 4,800 flying hours of which 650 on type.
- 51 hours and 25 minutes in the three previous months, all on type.
- 26 hours and 51 minutes in the previous month, all on type.
- 3 hours and 32 minutes in the previous 24 hours, all on type.
- Last Cat II/III precision approach performed on 10 January 2002.

The Co-pilot saw service as a French Navy pilot and simulator instructor between 1986 and 2000. At that time he flew the DA10, Nord 262, Bréguet Atlantique, Gardian and Cap 10. He was hired by Icare (see para. 1.17.2.1.1) on 13 November 2000, and completed an SFI training course with the DGAC's Operations and Aeronautical Training Department in February 2001. He became SFI at Icare on 29 April 2001 following completion of his type CRJ-100 qualification. He was appointed co-pilot on the CRJ-100 at Brit Air in October 2001, then SFI for Brit Air on 28 January 2002. He was based in Brest.

Note: As SFI, the Co-pilot had supervised the Captain's last base training in January 2003.

Work schedule in June:

- 1 to 3 June: rest period.
- 4 June: preparatory ground course on CRJ-100 simulator.
- 5 to 6 June: CRJ-100 simulator.
- 7 to 10 June: rest period.
- 11 to 15 June: flight.
- 16 to 17 June: rest period.
- 18 June: ground course and CRJ-100 simulator.
- 19 June: flight.
- 20 June: rest period.
- 21 June: ground course and CRJ-100 simulator from 9 h 30 to 16 h 45 in Morlaix.

On the day of the event, the Co-pilot had performed the same rotations as the Captain, namely:

Flight No.	Departure	Destination	Departure	Arrival	Role	Aeroplane
AF 5673	Brest	Nantes	16 h 20	17 h 03	PF	CRJ-700
AF 5773	Nantes	Strasbourg	17 h 33	19 h 00	PF	CRJ-100
AF 5772	Strasbourg	Nantes	19 h 25	20 h 47	PNF	CRJ-100
AF 5672	Nantes	Brest	21 h 05	-	PNF	CRJ-100

Same comments as for Captain.

1.5.1.3 Cabin crew

Female, aged 31.

- Safety and life-saving certificate obtained on 8 September 1994.
- Waiver from the Civil Aviation Medical Council on 28 June 2000.
- Last medical certificate obtained on 20 June 2003.
- Initial Brit Air training course performed on ATR 72, ATR 42 and SAAB 340 in March 1995.
- Training on CRJ-100 in April and May 1997.
- Last training refresher course performed 13 to 16 August, 2002.
- Last check flight performed 17 January, 2003.
- On day of accident, schedule as for flight crew.

1.5.2 Brest Guipavas Approach Controller

Female, aged 42.

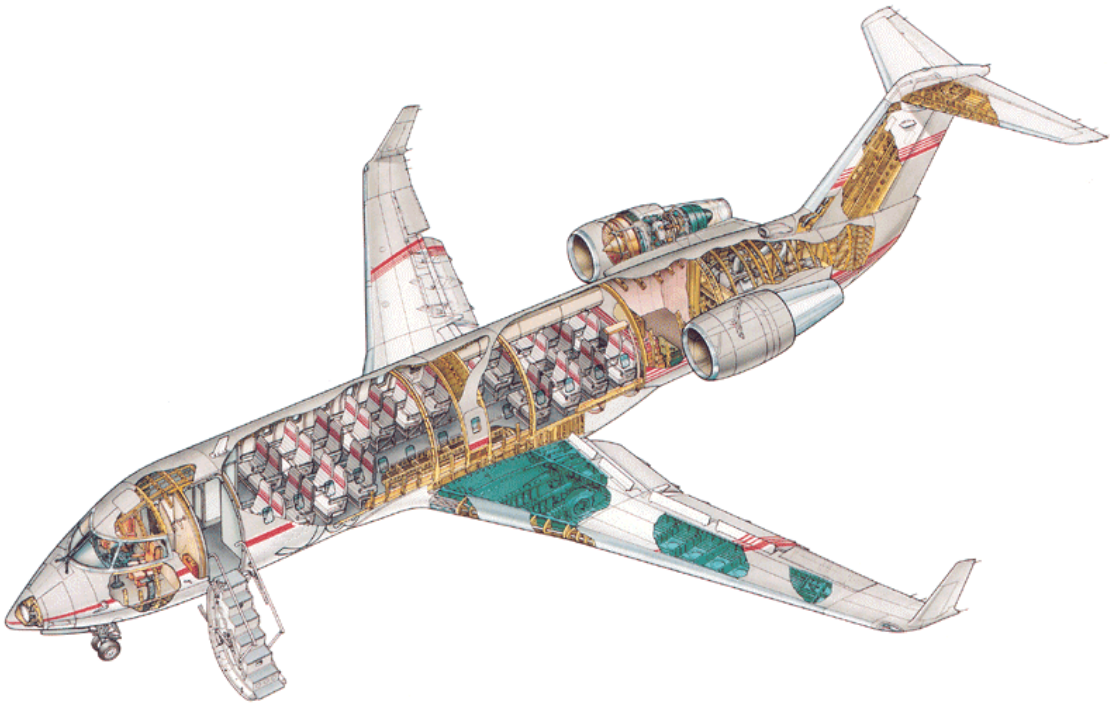
- Air Traffic Control Engineer.
- Radar approach controller qualification at Brest Guipavas obtained on 1 April 1997, valid until 31 March 2006.
- License for radar vectoring in the Brest-Iroise approach control airspace issued on 10 August 2001.

1.6 AEROPLANE INFORMATION

1.6.1 Airframe

The CRJ-100 is a twin jet-engine aeroplane with a maximum takeoff weight of 23,133 kg, a maximum landing weight of 21,319 kg, and a capacity of fifty passengers in the version used (F-GRJS).

- Manufacturer: BOMBARDIER INC. CANADAIR GROUP – Canada.
- Type: CANADAIR CL-600 2B 19 REGIONAL JET "CRJ-100".
- Serial number: 7377.
- Certificate of Airworthiness IM 208 dated 21 March 2000, valid until 17 March 2006.
- Date of entry into service: 21 March 2000.
- Utilization to 22 June 2003: 6,649 flying hours and 6,552 cycles.



The CRJ-100

1.6.2 Engines

- Manufacturer: GENERAL ELECTRIC - USA.
- Type: CF-34-3A1.

	Left	**Right**
Serial number	807611	807612
Flying time	6,645 hours	6,645 hours
Total number of cycles	6,556	6,556

1.6.3 Maintenance

The aeroplane was maintained by Brit Air under an approved maintenance program.

- Last annual overhaul on 20 January 2003 by Lyon Maintenance in Lyon.
- Last “C” check (5,000 flying hours) performed on 25 November 2002 by Brit Air in Morlaix.
- Last “A” check (500 flying hours) performed by Lyon Maintenance in Lyon on 11 June 2003.
- Last (combined) service check (72 hours) and routine check (100 flying hours) performed on 21 June 2003 by Brit Air in Brest.

The only acceptable deferred item on departure from Nantes related to the upper rear navigation light (inoperative bulb).

1.6.4 Weight and Balance

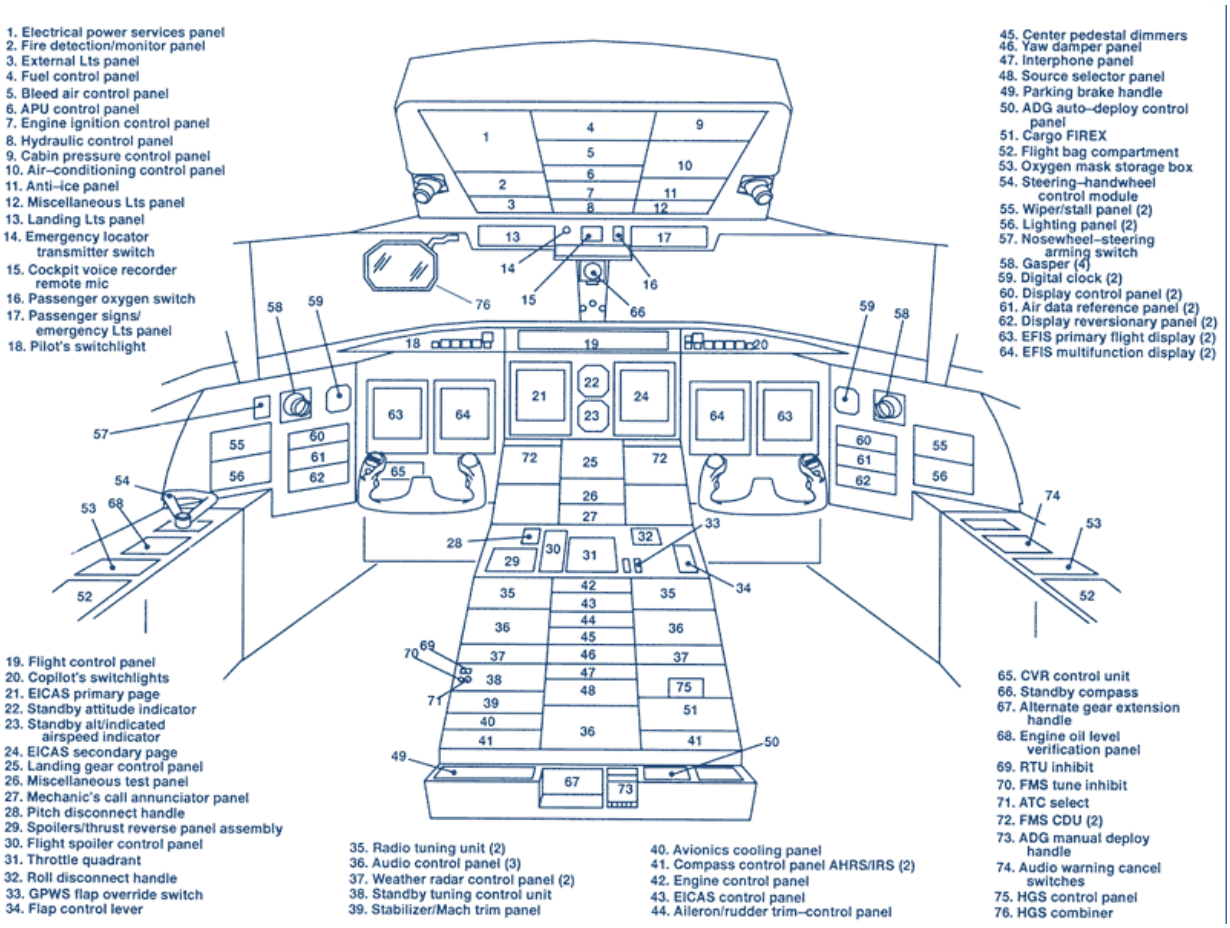
The aeroplane weight on takeoff from Nantes was 18,945 kg. The estimated landing weight was 17,945 kg. The fuel weight on takeoff was 2,800 kg; there was about 1,800 kg remaining in the tanks at the time of the accident.

The aeroplane centre of gravity was 16%, without any notable variations during the course of the flight; this is within the CG envelope limits (which are set between 9 and 35%).

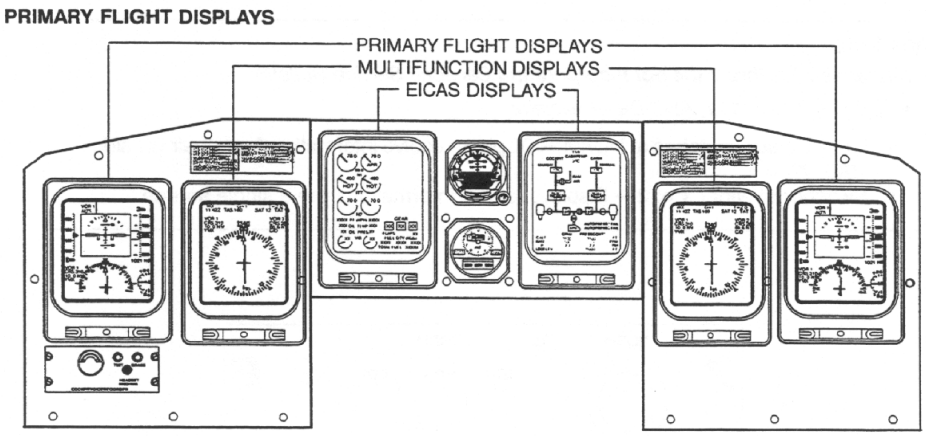
1.6.5 Equipment

1.6.5.1 Cockpit

1.6.5.1.1 General view

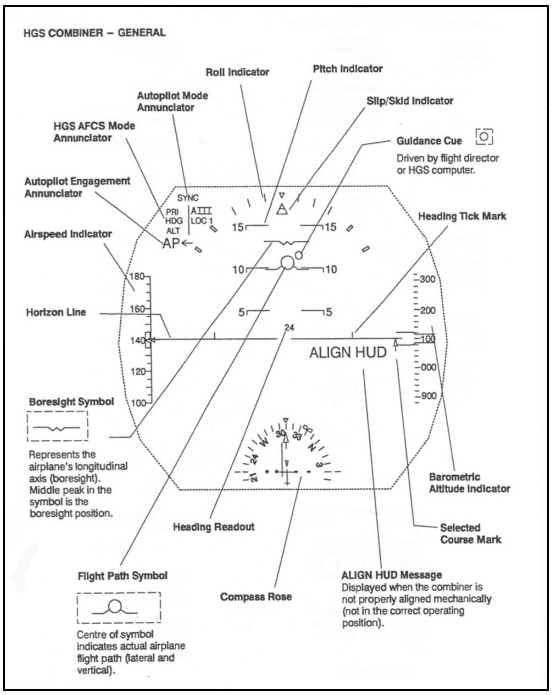


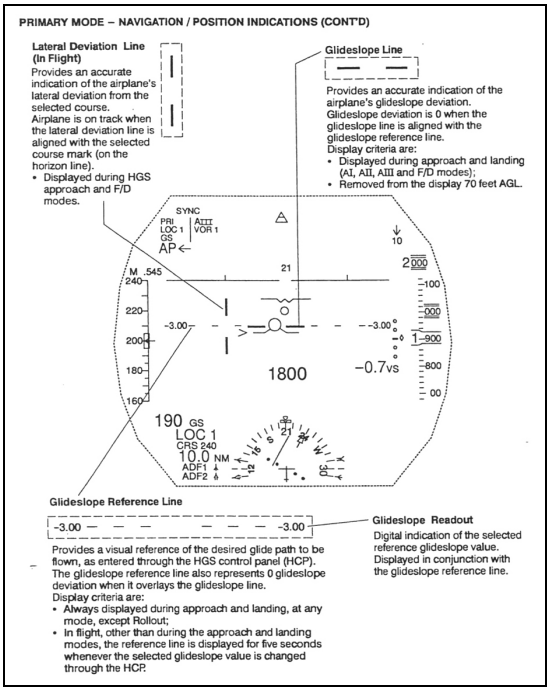
1.6.5.1.2 PFD / MD / EICAS



1.6.5.1.3 Head-up guidance system

The head-up guidance system (or HGS) is a flight instrument situated in the left-seat position. It displays superimposed imagery at head-up level, overlaid over the pilot's external field of view, in the form of digital or analogue symbols (in particular ILS information, airspeed and engine speeds).

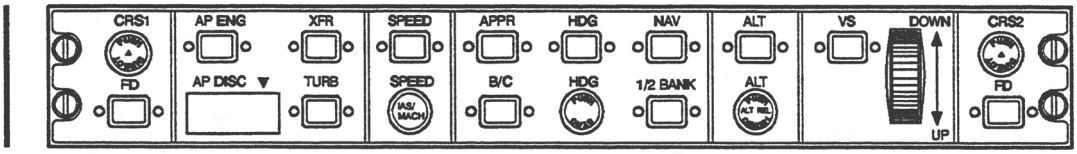




1.6.5.2 Automatic flight control system modes

The CRJ-100's automatic flight control system executes orders from the flight director, employing lateral and vertical modes to control the aeroplane in roll, pitch and yaw by generating the corresponding control-surface inputs. It is controlled by one of the two flight control computers (FCC1 – Captain or FCC2 – Co-pilot), depending on the crew selection.

The flight director provides visual guidance by displaying steering commands on the PFD in the form of perpendicular V-bars, to allow either manual aeroplane control or visual checking of the automatic flight control system's responses to steering commands. The latter are managed by automatic flight control system "modes", which are selected on the FCP (flight control panel, see Figure 1). The flight mode annunciator (FMA) situated in the upper part of the PFD (Figure 2) indicates the various active modes in green, and armed modes in white, at the same time separating the lateral and vertical modes (lateral modes being shown above vertical modes).



Flight Control Panel (1) – Glareshield

Figure 1

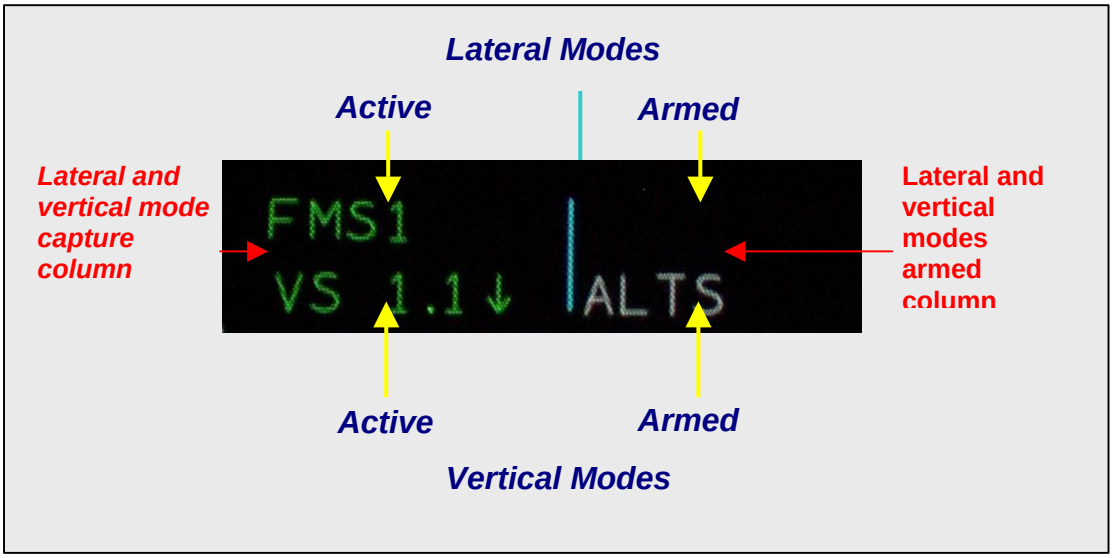


Figure 2

1.6.5.2.1 Lateral modes

Heading mode (HDG)

The heading mode provides lateral guidance that allows the heading selected by the crew to be followed. This mode is selected by pressing the "HDG" pushbutton switch on the FCP. The value selected via the heading selector pushbutton (also situated on the FCP), is displayed on the PFD heading cursor. When this mode is active, a green ‘HDG’ message appears in the lateral-mode capture column on the PFD.

Navigation mode (VOR, LOC, FMS)

The navigation mode allows capture and following of the navigation source displayed on the PFD. This mode arms when it is selected.

Note: Navigation may be performed from three different sources by using either the radio-navigation aids, (LOC source for navigation with a localizer; VOR source for navigation with VOR) or the FMS (FMS source). The source used is selected using the NAV SOURCE button on the Display Control Panel.

The navigation mode is selected by pressing the NAV pushbutton switch on the FCP. It is deselected either by pushing this button again, or by selecting another lateral mode, or by changing the navigation source.

When the navigation mode is armed, two messages are displayed: a green ‘HDG’ message in the lateral-mode capture column on the PFD, and a white message indicating the navigation source (VOR 1 or 2, LOC 1 or 2, or FMS 1 or 2) in the armed lateral mode column on the PFD. When the mode is active, a green message (VOR 1 or 2, LOC 1 or 2, or FMS 1 or 2) appears in the lateral-mode capture column on the PFD, instead of the HDG message.

Approach mode

The approach mode captures and follows the navigation source displayed on the PFD.

The approach mode is selected by pressing the APPR pushbutton on the FCP. Once the mode is armed, two messages are displayed on the PFD: a green ‘HDG’ message in the PFD "lateral mode" capture column, and a white message (VOR 1 or 2, LOC 1 or 2, or FMS 1 or 2) in the "armed lateral mode" column on the PFD. When the mode is active, a green message (VOR 1 or 2, LOC 1 or 2, or FMS 1 or 2) is displayed in the lateral-mode capture column of the PFD, instead of the HDG message.

The approach mode captures the localizer beam centreline provided it is initially armed and the gap between the aeroplane position and the localizer beam centreline is less than 0.25 points (“forced capture”). When a convergent heading with the localizer beam centreline is selected to intercept the centreline (“normal localizer capture”) and provided the approach mode has been armed, capture of the localizer beam centreline may occur if the deviation is less than 2.87 points.

1.6.5.2.2 Vertical modes

Vertical speed mode (VS)

The vertical speed mode is selected by pressing the "VS" pushbutton on the FCP. It maintains the reference vertical speed displayed by means of a rotary selector located on the right of the ‘VS’ pushbutton.

The green "VS #.# ↑" or "VS #.#↓" message is displayed in the vertical-mode capture column on the PFD.

Note: #.# corresponds to the value of the selected vertical speed reference, in thousands of feet per minute. The arrow indicates a positive or negative reference, depending on whether it is pointing up or down.

Capture and hold current altitude mode (ALT)

The altitude mode allows capturing and holding the current altitude of the aeroplane, i.e. the altitude at the moment of mode selection. This selection is made by pushing the ALT button on the FCP.

The green “ALT” message is displayed to indicate capture then holding of the current altitude. The value of the reference altitude is not displayed.

Capture and hold pre-displayed altitude mode (ALTS)

The "capture and hold pre-displayed altitude" altitude select mode allows capture and hold of a pre-displayed altitude selected using the ALT selector on the FCP. It is armed automatically as soon as VS is selected. A white "ALTS" message is displayed in the "armed vertical mode" column. The "ALTS" mode is activated upon capture of the pre-displayed altitude. The green “ALTS HEADING” message is then displayed, to be replaced by the "ALTS" message during altitude-hold.

Note: If the direction of the selected VS does not cause the aeroplane to pass through the pre-displayed altitude, the stated altitude will never be captured by “ALTS”.

When the ALTS mode is active, a new altitude must be selected before activating the vertical speed mode, failing which, if the pre-displayed altitude is the actual aeroplane altitude, capture will be immediate and the aeroplane will remain at this altitude. Selection of a new pre-displayed altitude results in transient activation of the ALT mode and arming of the ALTS mode for the new altitude.

Glideslope mode (GS)

Glideslope mode allows capture and following of a precision-approach glide path. The approach slope will not be captured unless the deviation of the aeroplane with regard to the approach slope is less than 10% of the maximum scale, i.e. 0.2 points.

Glideslope mode is armed automatically when the approach mode is selected with a valid localizer as the lateral navigation source.

When this mode is armed, the white "GS" message appears in the column of armed vertical modes on the PFD. During capture and following of the precision-approach glide path, the green “GS” message is displayed in the vertical-mode capture column on the PFD.

1.6.5.2.3 Go-around mode

The go-around mode allows following the heading selected on the FCP while limiting roll to five degrees, and also generates a ten-degree nose-up attitude indication. This mode is selected by pushing the TOGA buttons on the throttles. It disengages the autopilot, de-activates any other lateral and vertical flight modes that may be active, and activates the two flight directors.

The go-around mode is displayed by two green GA messages, on the PFD, one in the lateral-mode capture column and the other in the vertical-mode capture column.

1.6.5.3 Ground Proximity Warning System

The aeroplane was equipped with a Honeywell Ground Proximity Warning System (GPWS), Mk V Warning Computer model, P/N 965-0676-022.

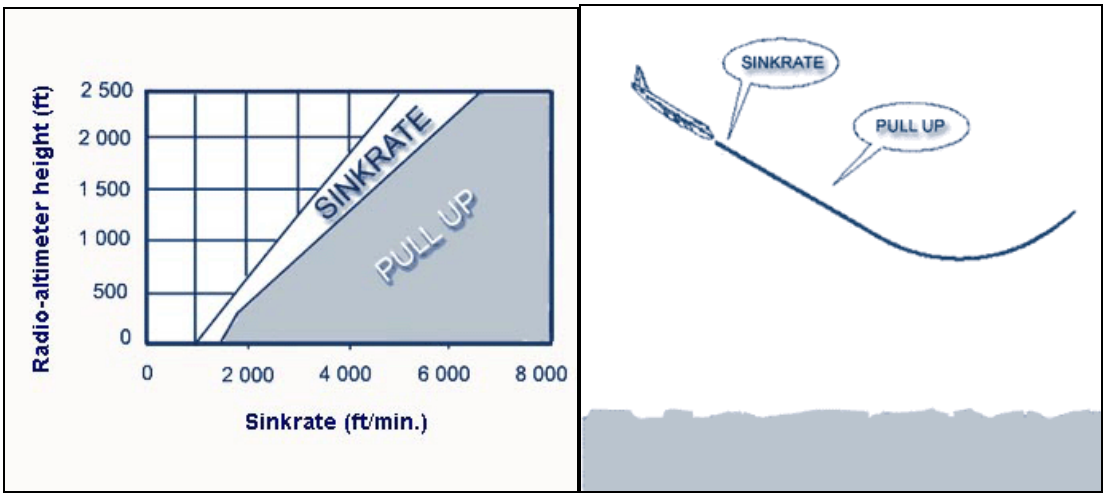
The GPWS is an on-board system which gives the crew aural and visual indications when the conditions of flight may present a risk of impact with the ground. These alarms are generated, among other reasons, for:

- excessive sink rate (mode 1);
- significant deviation below the glide slope (mode 5).

The GPWS also provides automatic height callout (mode 6).

Mode 1

Mode 1 provides a warning or an alarm in the event of excessive rate of descent near the ground. A warning envelope and an alarm envelope are defined in relation to the radio-altimeter height and the rate of descent. If the aeroplane enters the warning zone, the "Sink rate" aural warning sounds and the red GPWS light flashes. If the aeroplane enters the alarm zone, the "Whoop whoop Pull up" aural warning is generated until the aeroplane exits the warning envelope, and the GPWS light flashes.



Mode 1 – Excessive rate of descent

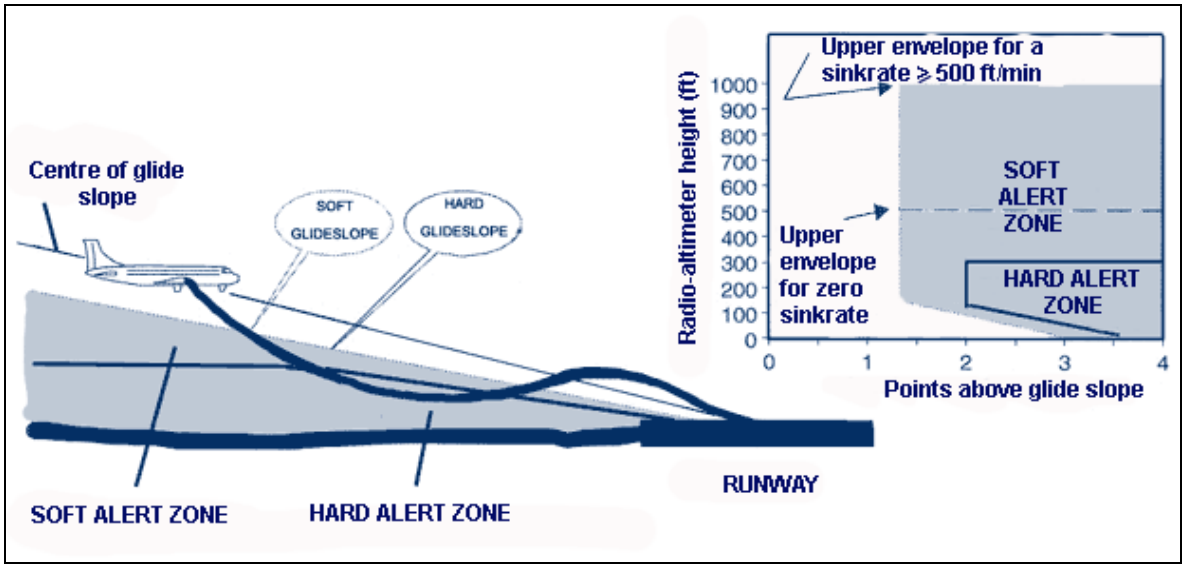
Mode 5

Mode 5 supplies two warning levels if the aeroplane passes significantly beneath the axis of the glide slope beam during an ILS approach.

The first warning level is generated if the aeroplane deviates more than 1.3 points under the glide slope beam below one thousand feet. The "Glide slope" aural warning sounds at half the intensity (dB level) of the other aural warnings, and the amber G/S light flashes.

The second warning level is generated below a radio-altimeter height of three hundred feet where the deviation under the glide slope is greater than two points. The "Glide slope" aural warning sounds at normal volume, and the G/S light flashes.

Mode 5 can be inhibited below one thousand feet radio-altimeter height, by pressing one of the two G/S or GPWS annunciator pushbuttons. Mode 1 announcements have priority over those of mode 5.



Mode 5 – Excessive deviation under the glide slope

Mode 6

Types of callout:

- In the landing gear extended configuration, a "Minima" aural warning sounds as the aeroplane passes through the decision height, if a decision height has been selected. On the other hand, no such warning is issued if the decision height is displayed.

- When passing through specific heights: 500, 400, 300, 200, 100, 50, 40, 30, 20 and 10 feet.

1.6.5.3 Emergency Beacon

The aeroplane was equipped with a Socata ELT 96 406-megahertz emergency beacon. The beacon did not trigger during the accident.

The last maintenance operation (reliability check) had been performed by Brit Air on 20 January 2003 and was satisfactory.

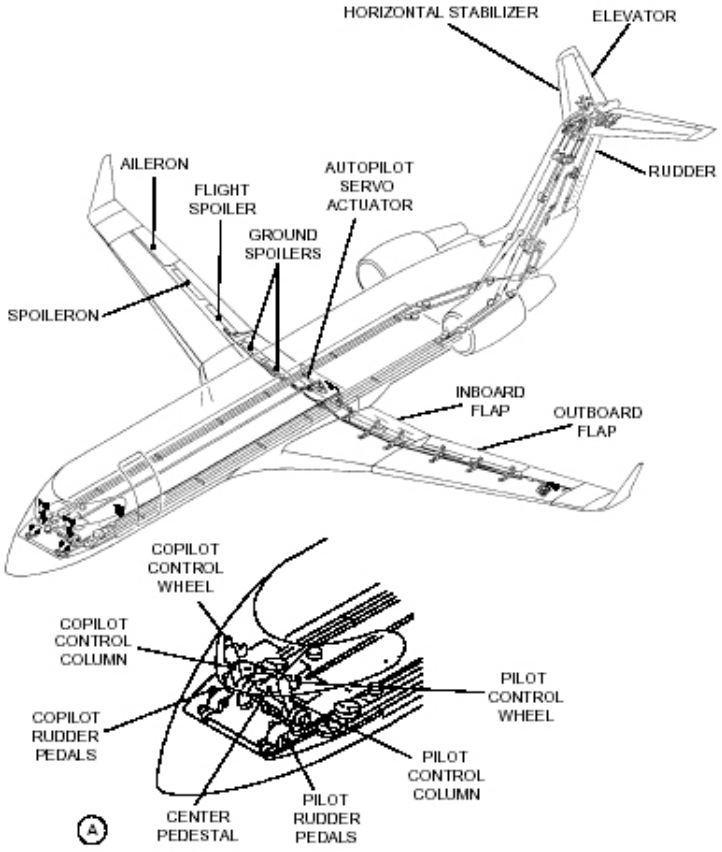
The role of the beacon is to transmit a distress signal in the event of an accident, on the 406.025 MHz and 121.5 MHz frequencies. This signal, captured by the SARSAT/COSPAS satellite system, is transmitted to the mission control centre (MCC) in Toulouse. Analysis of the signal provides the identification and geographical position of the aeroplane, with a precision of approximately one kilometre. The audible signal from the beacon, transmitted on 121.5 MHz, can be heard in control towers, which continuously monitor this frequency.

The Emergency Beacon is situated in the CRJ-100 tail cone. It includes a printed circuit board for broadcasting the distress signal, and a distress-signal triggering assembly comprising a sensor printed circuit board and a G-switch printed circuit board. It also has a three-position selector, "OFF", "AUTO" and "MAN/RESET".

The Emergency Beacon is connected electrically to an antenna situated on the tail cone, and to an electronics unit in the avionics compartment and a control unit in the cockpit.

1.6.5.5 Pitch control channel

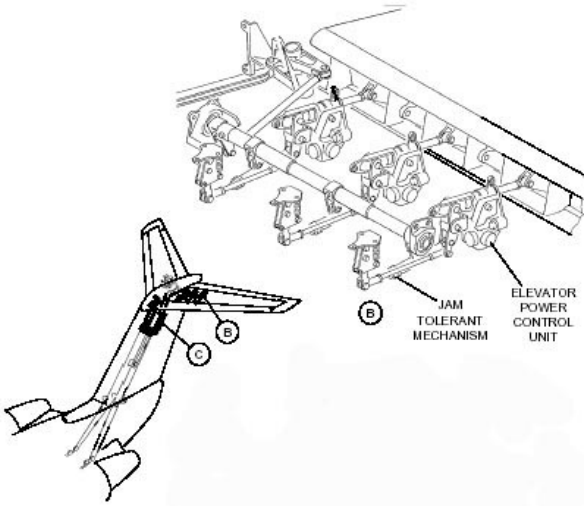
Aeroplane movements in the vertical plane are controlled by two elevators (left and right) and a stabilizer located on the tail.



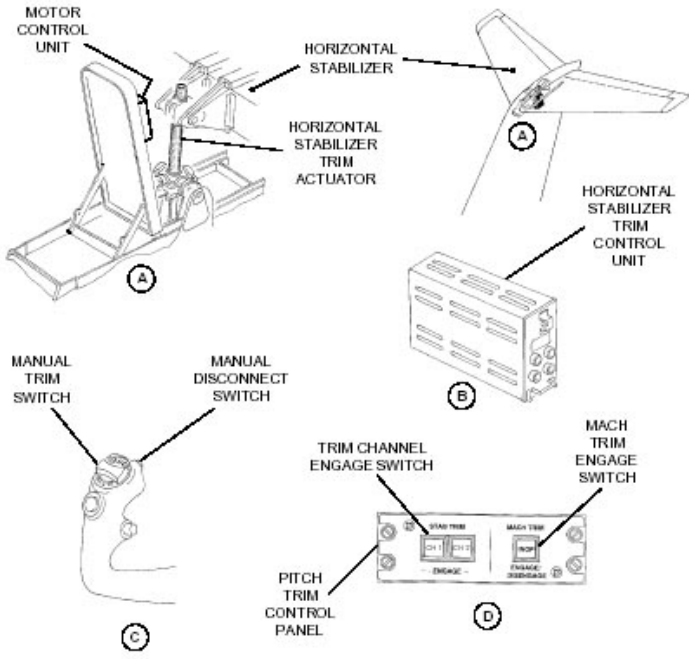
The two elevators are linked to the control columns in the cockpit (left control surface to left control column and right control surface to right control column), by means of cables, pulleys, metal rods and hydraulic actuators (three per control surface). They are also interconnected, and move simultaneously.

Both elevators can also be controlled by the automatic flight control system, via a servo-actuator consisting of two parts (primary servo and mount servo).

The control-surface position is indicated in the cockpit, on the EICAS "flight controls" page. The operating range lies between 23° UP and 18° DOWN.

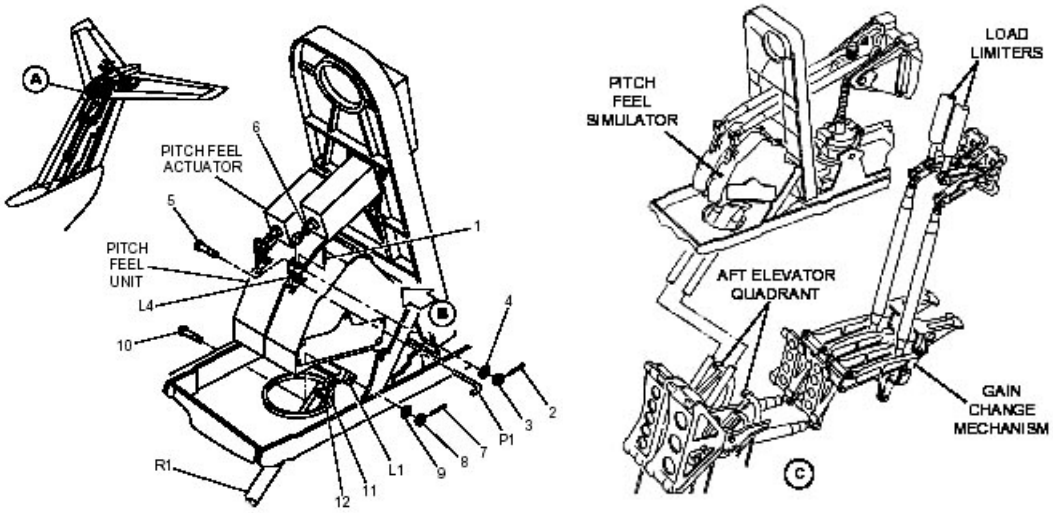


The horizontal stabilizer controls the aeroplane pitch. It is actuated mechanically by a worm gear (horizontal stabilizer thrust actuator, HSTA) driven electrically by a motor (MCU, motor control unit). This motor receives control inputs from the trim control switch on the captain’s or the co-pilot's control column, depending on the crew selection.



The horizontal stabilizer can also be controlled via the automatic flight control system. Its position is indicated in the cockpit, on the EICAS "flight controls" and "status pages". The operating range is between -13 and +2°.

The pitch control channel additionally includes an artificial pitch feel system, designed to allow the crew to feel aerodynamic forces on the elevators. It comprises two pitch feel simulator units (PFSU), each connected to a linear pitch feel actuator.



1.6.5.6 Onboard safety and emergency equipment

In addition to the standard equipment stowed under each passenger seat, F-GRJS also carried a megaphone, torches, a halon fire extinguisher and a first-aid kit stowed at the front of the cabin, and an H_2O extinguisher at the rear of the cabin. There was also a halon extinguisher in the cockpit.

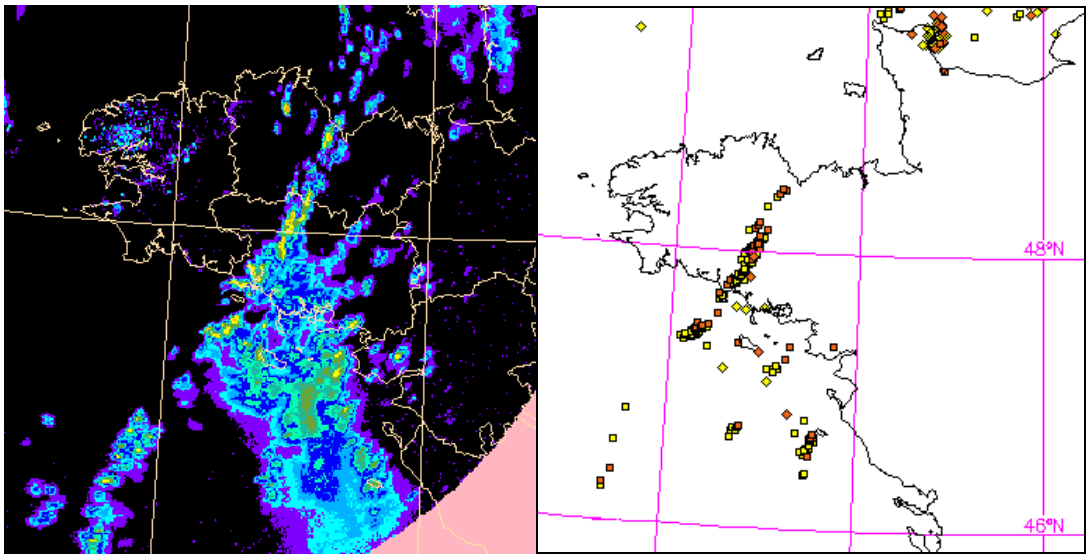
Note: the order of 12 May, 1997 (OPS 1) does not impose carrying a megaphone.

1.7 METEOROLOGICAL INFORMATION

1.7.1 General situation

At 18 h 00, the situation over the west of France, western Brittany and North Biscay was characterized by a massive flat low associated with a mass of warm, wet air, favouring the development of convection cells. These were moving in a south-south-westerly stream at altitude, while ground winds were light and variable.

Over the Bay of Biscay, a line of squalls was developing, with heavy precipitation and numerous storms reaching Brittany, moving along a line from Lorient to St. Brieuc from 21 h 00 onwards. Turbulence and moderate to heavy icing was associated with the line of squalls.



(images supplied by Météo France)

The above two images, timed at 21 h 45, represent: on the left, position and intensity of precipitation and, on the right, lightning strikes on the ground.

1.7.2 Situation at Brest Guipavas

From 18 h 00, fairly inactive cumulonimbus was present over Guipavas and was moving slowly away towards the northeast. At around 20 h 30, sea air was entering the region, occasionally reducing visibility to eight hundred meters and the cloud base to one hundred feet.

This type of situation leads to very significant variations in visibility in time and in space.

METARs issued at 21 h 30 and 22 h 00:

222130Z 32005KT 280V350 0800 R26/P1500 FG BKN002 SCT020CB 15/15 Q1007 NOSIG =

222200Z 32009KT 280V360 0800 R26/1400VP1500 FG BKN002 SCT020CB 15/15 Q1008 NOSIG =

1.7.3 Flight Dossier

1.7.3.1 Information supplied to the crew

The flight dossiers supplied to crews at stopovers include a meteorological file that is not archived by the station. The flight dossier supplied at Nantes by the aeroplane dispatcher was destroyed in the fire that followed the accident. It most likely contained:

- the METAR issued at 20 h 30 min (LFRB 222030Z 31011KT 4000 BR BKN002 SCT020CB 16/15 Q1006 NOSIG =);
- the TAF issued at 20 h 00 and valid from 21 h 00 to 06 h 00 (LFRB 222000Z 222106 06005KT 9999 SCT020CB BKN100 TEMPO 2124 25015KT 6000 TSRA BKN015CB BECMG 0003 VRB03KT 9999 SCT040 PROB30 TEMPO 0306 400 FG OVC002);
- the TEMSI EUROC issued 21 h 00 (appendix 1);
- the TEMSI France issued 18 h 00 (appendix 1);
- wind charts.

1.7.3.2 TAF amendment

The TAF issued at 20 h 00, which made no mention of the possibility of fog between 21 h 00 and 3 h 00, was amended at 21 h 05 min:

LFRB 222000Z 222106 06005KT 3000 BR TEMPO 2106 0600 FG BKN002 TEMPO 2124 25015KT 4000 TSRA BKN015CB

This was too late for the crew to have known about. On departing Nantes, the crew would therefore have had no knowledge regarding the presence of fog on arrival at Brest. None of the documents in the crew's possession, the METAR issued at 20 h 30 the (non-amended) TAF issued at 20 h 00, and the previous METARs and TAFs, mentioned the presence of or possibility of fog.

1.7.4 Meteorological information received in flight

The Co-pilot listened to the Brest ATIS information at 21 h 21 min 15 s (appendix 1).

At 21 h 44 min 21 s, the Brest approach controller indicated that fog "has descended on the airport".

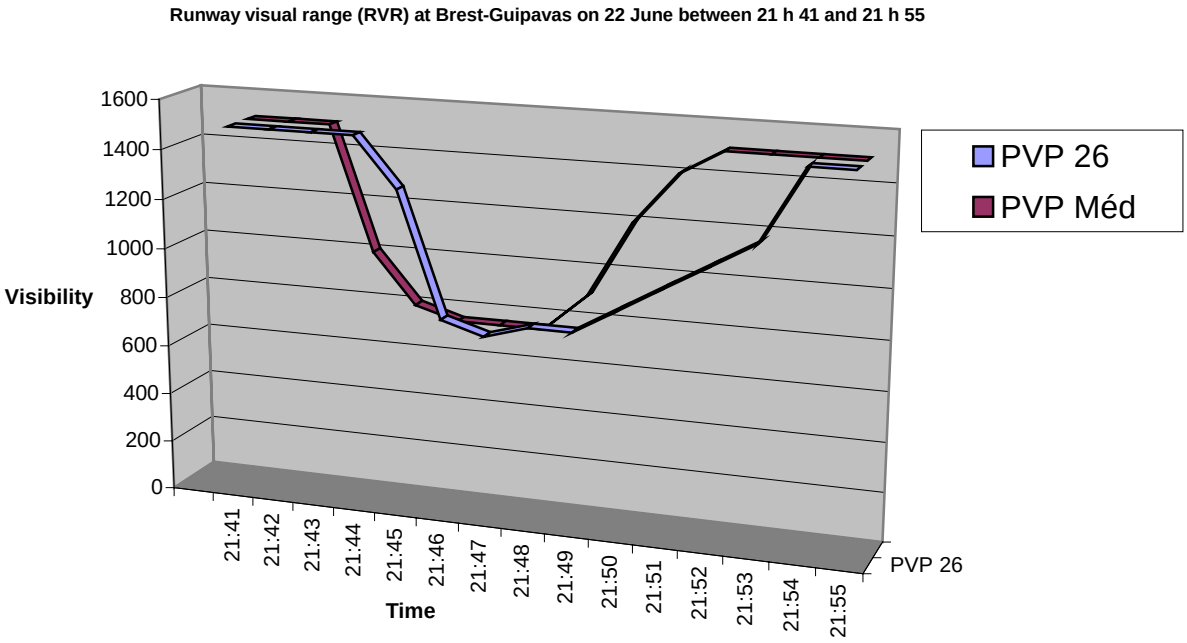
At 21 h 45 min 42 s, the controller called the preceding flight (Charter 801), saying: "Three one zero degrees, nine to fifteen knots, runway is wet, cloud base two hundred feet".

At 21 h 45 min 54 s, the controller called Charter 801 with: "RVR at threshold one thousand three hundred meters mid-runway eight hundred metres".

At 21 h 49 min 35 s, while clearing F-GRJS for landing, the controller specified: "Three two zero degrees, eight to fifteen knots, cloud base now less than one hundred feet". At 21 h 49 min 51 s he added "and RVR's eight hundred meters and nine hundred meters".

These various messages were either read back or commented on by the crew.

1.7.5 Evolution in Brest Runway 26-L RVR's during the approach



Threshold 26 = transmissometer through the threshold of Runway 26 Left.
Median = second transmissometer through the runway centre point.

The rapid variation in the RVR's indicate the passage of fog banks. These indications nonetheless should be interpreted cautiously, since the location of the accident was over two kilometres from the runway threshold.

1.8 Aids to Navigation

The approach procedures to Runway 26 Left at Brest Guipavas are based on the following means:

- the GU locator on the 338 kHz frequency;
- the Runway 26 Left BG ILS, on the 109.900 MHz frequency, associated with DME installed coaxially with the glideslope transmitter; the localizer beam is on the runway extended centreline; the glideslope is set at 5.2%;
- the Outer Marker located 4 NM from the threshold of runway 26 Left;
- high intensity lighting systems including nine hundred meter centreline approach lights, green unidirectional threshold lights, white runway sidelights, ICAO-type runway centreline lights, and a touchdown zone (TDZ).

The 26-Left ILS complies with Class III E 4. It permits Category-III approaches.

NOTAM B 2771 03 indicated that Category II and III approaches were unavailable from 2 June to 31 July 2003. An internal memo within civil aviation departments specified that drainage works around the radio installations no longer made it possible to guarantee Category II and III approaches.

A check on all of the radio installations at Brest Guipavas aerodrome was carried out on Friday 20 June 2003. No anomalies were found.

Four minutes before F-GRJS, a Boeing 737, call sign France Charter 801, had performed an ILS approach to Runway 26 Left. The crew of that aeroplane did not mention any malfunctions.

On Tuesday 24 June 2003, when a specialized team from the DGAC/STNA carried out an in-flight calibration of the ILS, the equipment was performing to specifications.

1.9 TELECOMMUNICATIONS

1.9.1 Radio communications

After leaving the Nantes control area, the crew was in contact, successively, with the following ATC services:

- Brest Control, control sector "ID" (Lower Dinard), on the 125.500 MHz frequency;
- Iroise Approach (Brest approach call-sign), on the 135.820 MHz frequency;
- Brest Guipavas Tower, on the 120.100 MHz frequency.

The following is a transcript of the exchanges recorded by Brest Tower:

Transmitting Station	Receiving Station	UTC time	Communications (content)
AIS 801	TWR/APP	21 h 34 min 42 s.	Brest, France Charter eight zero one hello
TWR/APP	AIS 801	21 h 34 min 48 s.	France Charter eight zero one hello
AIS 801	TWR/APP	21 h 34 min 50 s	Eight zero one on descent to uh … sixty
TWR/APP	AIS 801	21 h 34 min 53 s	Charter eight zero one descend to three thousand feet QNH uh… a thousand and seven cleared for ILS approach two-six.. uh ..... report when established on localizer
AIS 801	TWR/APP	21 h 35 min 01 s	Three thousand feet a thousand and seven and report when established on localizer two-six France Charter eight zero one
TWR/APP	AIS 801	21 h 35 min 16 s	Charter eight zero one maintain speed uh… high until BODIL if possible

AIS 801	TWR/APP	21 h 35 min 21 s	Roger, will maintain till BODIL
BZ 672 EC	TWR/APP	21 h 39 min 23 s	Iroise uh good evening Brit Air six seven two Echo Charlie descending to level seven zero uh … towards BODIL avoiding the storms
TWR/APP	BZ 672 EC	21 h 39 min 31 s	Brit Air Echo Charlie, descend four thousand feet QNH one thousand and eight number two on approach plan a holding pattern at Golf Uniform
BZ 672 EC	TWR/APP	21 h 39 min 41 s	Yes and well uh we'll reduce a bit and so we're planning a holding pattern descending to Four Thousand feet QNH one thousand and eight for Echo Charlie
TWR/APP	BZ 672 EC	21 h 39 min 51 s	That's correct
TWR/APP	BZ 672 EC	21 h 41 min 45 s	Echo Charlie reduce speed minimum in smooth
BZ 672 EC	TWR/APP	21 h 41 min 49 s	OK we reduce speed minimum in smooth uh Brit Air Echo Charlie
AIS 801	TWR/APP	21 h 43 min 43 s	Established on loc uh… France Charter eight zero one
TWR/APP	AIS 801	21 h 43 min 46 s	Zero one continue the approach report when passing the Outer Marker
AIS 801	TWR/APP	21 h 43 min 49 s	Report at Outer eight zero one
TWR/APP	BZ 672 EC	21 h 44 min 21 s	Brit Air Echo Charlie descend to Three Thousand feet QNH one thousand and eight and make a holding pattern the fog has descended on the airport I'm not going to make you I'm not going to be able to let you approach straight away
BZ 672 EC	TWR/APP	21 h 44 min 33 s	Okay well then we're going to hold then uh descending to Three Thousand feet for Echo Charlie
TWR/APP	BZ 672 EC	21 h 44 min 41 s	That's correct
TWR/APP	AIS 801	21 h 45 min 42 s	Charter eight zero one cleared for landing on two-six left three hundred ten degrees nine to fifteen knots the runway is wet cloud base two hundred feet
AIS 801	TWR/APP	21 h 45 min 51 s	Landing two-six left France Charter eight zero one
TWR/APP	AIS 801	21 h 45 min 54 s	RVR threshold one thousand three hundred meters mid-runway eight hundred meters

AIS 801	TWR/APP	21 h 45 min 58 s	Roger
TWR/APP	BZ 672 EC	21 h 47 min 40 s	Echo Charlie descend Two Thousand feet QNH one thousand and eight
BZ 672 EC	TWR/APP	21 h 47 min 43 s	Descending Two Thousand feet QNH one thousand and eight Echo Charlie
TWR/APP	BZ 672 EC	21 h 48 min 01 s	Brit Air Echo Charlie the preceding aeroplane has landed you may continue the approach, report at Outer Marker
TWR/APP	BZ 672 EC	21 h 48 min 18 s	Echo Charlie?
BZ 672 EC	TWR/APP	21 h 48 min 19 s	Yes Echo Charlie
TWR/APP	BZ 672 EC	21 h 48 min 21 s	Are you ready for the approach?
BZ 672 EC	TWR/APP	21 h 48 min 22 s	Affirmative
TWR/APP	BZ 672 EC	21 h 48 min 23 s	Report at Outer Marker
BZ 672 EC	TWR/APP	21 h 48 min 24 s	We will report at Outer Marker Echo Charlie
TWR/APP	AIS 801	21 h 48 min 34 s	Eight zero one Exit Charlie then Papa
TWR/APP	AIS 801	21 h 48 min 42 s	Charter eight zero one it will be the next on the right
AIS 801	TWR/APP	21 h 48 min 34 s	Yes straight on the right eight zero one
TWR/APP	BZ 672 EC	21 h 49 min 35 s	Brit Air Echo Charlie cleared for landing on two-six left three twenty degrees and eight to fifteen knots cloud base now below one hundred feet
BZ 672 EC	TWR/APP	21 h 49 min 45 s	Roger so uh we will land on runway two-six left uh Echo Charlie
TWR/APP	BZ 672 EC	21 h 49 min.51 s	And the RVR's at eight hundred meters and nine hundred meters
BZ 672 EC	TWR/APP	21 h 49 min 54 s	Roger
TWR/APP	AIS 801	21 h 50 min 00 s	Charter eight zero one can you see the marshaller?

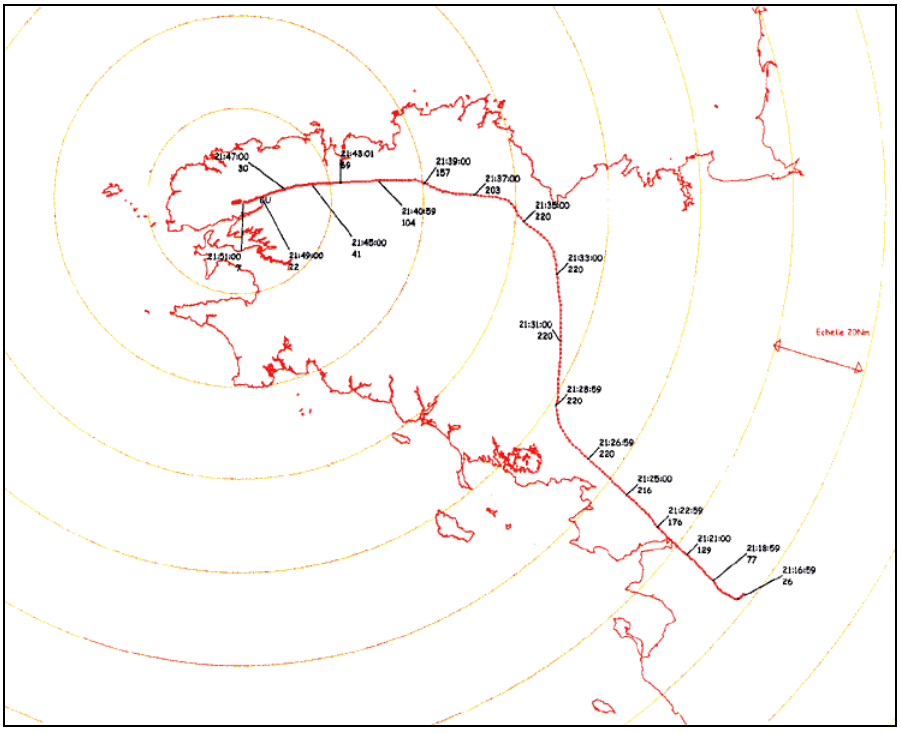
AIS 801	TWR/APP	21 h 50 min 06 s	Yeah (affirm)
TWR/APP	AIS 801	21 h 50 min 07 s	(Call) the marshaller, goodnight
AIS 801	TWR/APP	21 h 50 min 08 s	Goodnight
TWR/APP	BZ 672 EC	21 h 52 min 58 s	Brit Air Echo Charlie?
TWR/APP	BZ 672 EC	21 h 53 min 33 s	Brit Air Echo Charlie Guipavas?

1.9.2 Radar recordings

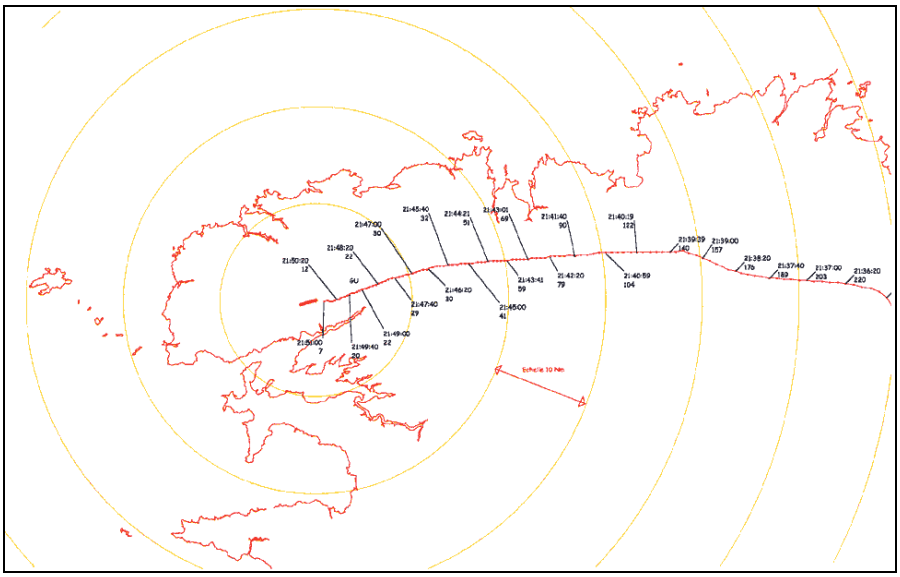
The Brest CRNA is equipped with a monopulse radar having a range of 250 NM. The antenna makes one complete rotation every eight seconds.

The quality of the data provided is checked twice a year by reading out the recordings. A check was performed on 27 June 2003 and demonstrated that the equipment was operating to specifications.

The recorded data made it possible to reconstitute the track of flight AF 5672 from its take-off from Nantes aerodrome (ELVIRA playback).



Radar track of flight AF 5672



Approach of flight AF 5672 to Brest Guipavas

Note: The labels show the time, and the altitude broadcast by the encoding altimeter (expressed in hundreds of feet). The reference time is specific to the radar.

An examination of the radar track shows that radar contact was lost between 21 h 49 min 49 s and 21 h 50 min 44 sec (FDR time reference). Various users of the Brest system concur that this equates to the usual area of lost radar contact.

1.10 Aerodrome Information

1.10.1 Infrastructure

Brest Guipavas is a controlled civilian aerodrome open to public air transport. It has two parallel runways: 08L/26R, to the north, is 700 x 18 meters; the other, 08R/26 L, to the south, is 3,100 x 45 meters. The aerodrome's reference altitude is 325 feet and the altitude of the threshold of runway 26L (26 Left) is 312 feet.

The aeroplane rescue and fire-fighting services (RFFS) protection level is 7 (ICAO classification), which corresponds to five people equipped with a light vehicle and two emergency vehicles.

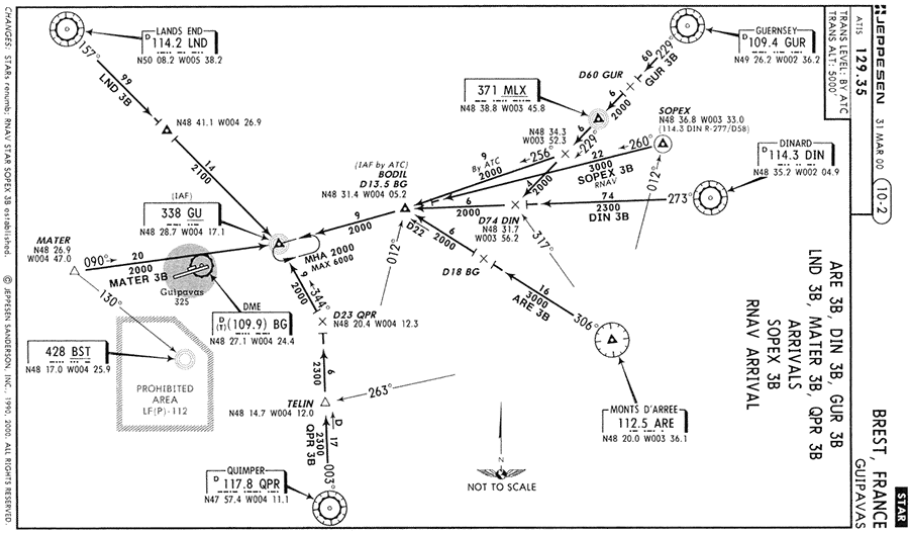
The aerodrome is equipped with two horizontal transmissometers, one at the threshold of runway 26 Left and the other in the middle of the runway. They allow runway visual range (RVR) to be measured. The aerodrome also has a cloud height meter that allows the cloud base height to be measured.

1.10.2 Situation at the time of the accident

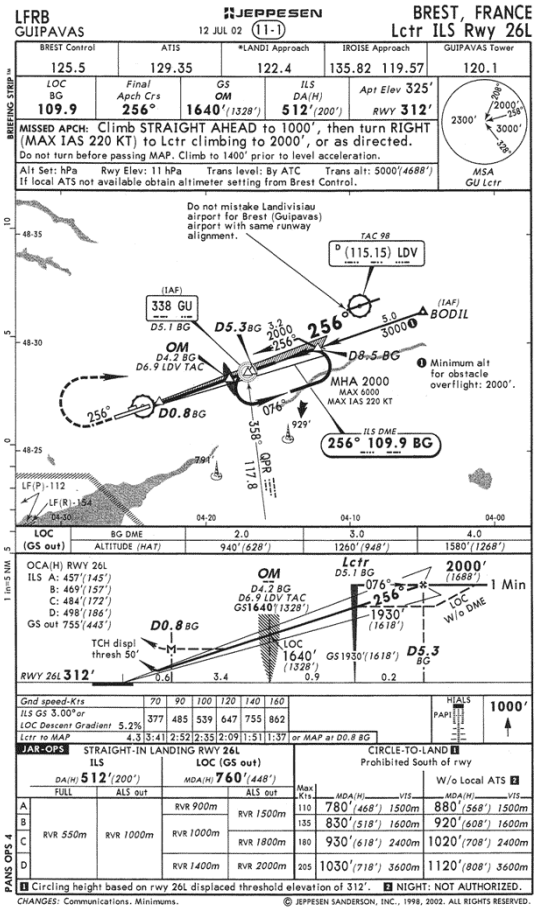
At the time of the accident, the active runway was 26 Left.

1.10.3 ILS arrival procedure on Runway 26 Left

Brit Air crews use Jeppesen documentation. The ILS 26 Left arrival and approach charts are reproduced hereafter. The aerodrome chart is reproduced in Appendix 2.



Arrival chart

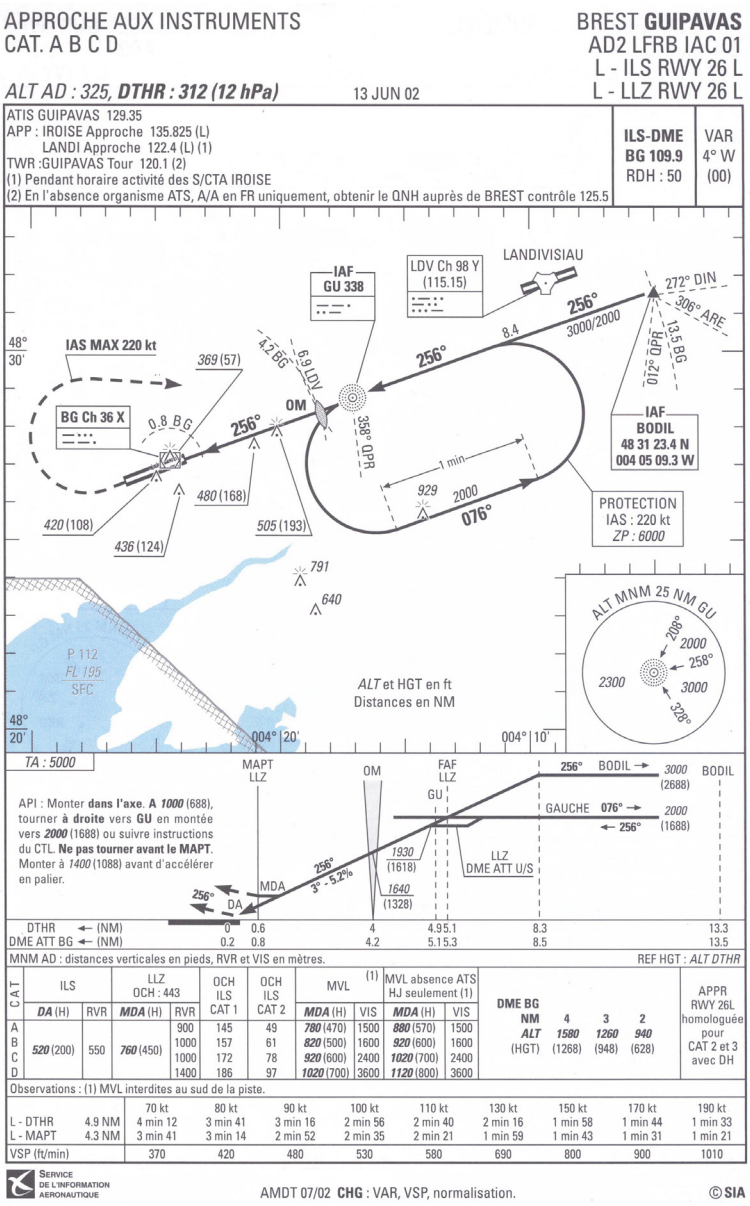


26 Left ILS approach chart via BODIL

The ILS Locator 26L approach is detailed on the official IAC chart[6], reproduced below. It starts over the initial approach fix (IAF), BODIL, at 3,000 ft on a radial of 076 degrees from GU, inbound (course 256°) until interception of the glide slope at a range of 8.5 NM DME from BG. The descent slope is 5.2%. The glide path passes over GU at 1,930 ft and 5.1 NM DME from BG. The lower ceiling of the holding pattern is set at 2,000 ft. Once out of hold, the procedure consists in intercepting the glide slope at 2,000 ft and 5.3 NM DME from BG.

Notes:

- The published decision altitude is 520 feet; on the Jeppesen approach chart, it is 512 feet.
- On the IAC chart, the approach is represented in the vertical plane from 3,000 ft, whereas it is only represented below 2,000 ft on the Jeppesen chart. Consequently, interception of the glide slope at 3,000 ft and 8.5 NM DME is not shown by Jeppeson.



[6] The procedure described in the Preliminary Report was obtained from the Jeppesen chart, which is not in strict accordance with the officially published chart.

1.11 Flight Recorders

1.11.1 Types and Readout Operations

F-GRJS was equipped with two L3COM protected recorders: one flight data recorder (FDR) and one cockpit voice recorder (CVR).

FDR
- Type: F1000.
- Type number: S800-2000-00.
- Serial number: 01198.

This is a solid-state memory recorder with a loop recording time of at least twenty-five hours.

CVR
- Type: S200.
- Type number: S200-0012-00.
- Serial number: 00346.

The solid-state memory of this type of CVR allows a recording duration of two hours. The following recordings are made on it:

- channel 1: UTC time coded by an acoustic signal,
- channels 2 and 3: VHF communications, cabin announcements, alarms and synthetic voice of the aeroplane,
- channel 4: cockpit area microphone: exchanges between crew members, background noises, alarms and synthetic voice response by the aeroplane.

When the pilots are using the boom microphones on their headsets, their voices are recorded respectively on channels 2 and 3.

Recording on channel 4 is continuous for two hours. Channels 1 to 3 are then mixed for the first ninety minutes, then separated for the last thirty minutes.

The recorders were taken under seal to the BEA on 23 June 2003. They were in good condition and were able to be read out on arrival.

1.11.2 CVR readout

The external connector on the protected box of the CVR was intact and was used for memory-readout. Only one hour of memory was recorded, corresponding to the full duration of the accident flight.

Note: The pre-flight cockpit procedure includes a CVR test by pressing a button in the cockpit. The button is placed next to another one allowing erasing of the content of the previous recording.

Since the pilots were not wearing headsets fitted with a boom microphone, their conversations were recorded by the cockpit area microphone (CAM) only (channel 4).

An ICAO standard (see Annex 6, Part I, paragraph 6.20) obliges crew members to communicate through a headset microphone or a dynamic throat microphone below the transition level or altitude. France notified a difference in relation to this measure.

Given the poor quality of the signal, the tools currently used by the BEA for voice identification (mainly spectral analysis) did not allow identification of speakers. The only means available to the investigators was therefore their experience, and non-quantifiable subjective criteria (including roughness of voice and impulsiveness of announcements).

The preliminary transcript of the recording was drafted after numerous playbacks. Since certain points could not be clarified, the investigators proposed that the surviving pilot participate in the readout process. His assistance allowed a more precise transcript to be made.

Some additional analyses were undertaken at the Police Forensic Laboratory, which is specialized in voice identification. The laboratory's specialists themselves encountered the same difficulties. They nevertheless confirmed the work performed with the help of the Co-pilot.

Synchronization was also performed with the FDR data. The resulting transcript is presented in Appendix 3. A limited number of points that could not be completely clarified are noted. From the transcript, the following information was obtained:

The crew was initially cleared to climb to flight level 180 and to head directly for BODIL.

At 21 h 21 min 15 s, the Co-pilot listened to the Brest ATIS and gave the Captain information regarding the active runway, visibility, cloud conditions and the QNH.

For the next thirteen minutes, the cockpit conversations concern almost exclusively the storm cells encountered in flight. The crew asked for clearance to climb to FL 220 and have free choice of heading, in order to avoid cumulonimbus, which the controller accepted.

At 21 h 36 min 17 s, information concerning the ILS, the number of the approach chart, the frequency of the "GU" NDB, and the decision altitude were stated by the Captain.

At 21 h 36 min 24 s, the Co-pilot asked to begin the descent.

At 21 h 36 min 43 s, the en-route controller asked them to reduce the aeroplane's speed, which was then number two.

At 21 h 37 min 02 s, the “top-of-descent” check-list was performed at the initiative of the Co-pilot.

At 21 h 39 min 31 s, the approach controller asked the crew to plan for a holding pattern at GU.

At 21 h 39 min 55 s, the Captain said “[…] displayed one thousand and eight on centre”.

At 21 h 44 min 21 s, the approach controller told the crew to descend to 3,000 ft QNH and perform a holding pattern given that fog “has descended on the airport”. The Co-pilot confirmed “Okay well then we’ll hold -- uh descending to Three Thousand feet for Echo Charlie”.

At 21 h 44 min 48 s, the Captain mentioned the possibility of performing a Category II precision approach. The Co-pilot pointed out that the aerodrome was restricted to Category I precision approaches.

At 21 h 47 min 40 s, the controller cleared the flight to descend to 2,000 ft QNH.

At 21 h 48 m 01 s, the controller told the crew to continue the approach, the previous aeroplane having landed, and to report when they had crossed the Outer Marker. The Co-pilot read back but the message was not received by the controller. At 21 h 48 min 18 s, the controller asked the crew if they were ready for the approach, and to report when at the Outer Marker. The Co-pilot answered “Affirmative” and read back about reporting at the Outer Marker.

Note: The first readback was effectively transmitted, as confirmed by recording of a value for the “VHF keying” parameter, but it was not received by the Control Tower, as seen from the ground radio communications recording. It has not been possible to explain non-reception of this message.

The Captain then called for the pre-landing check-list, which was performed between 21 h 49 min 26 s and 21 h 49 min 35 s.

At 21 h 49 min 35 s, the crew was cleared to land on Runway 26 left and the controller provided the latest weather information: “three twenty degrees, eight to fifteen knots, cloud base now less than one hundred feet”, followed by “RVR’s eight hundred meters and nine hundred meters”.

At 21 h 49 min 56 s, the Co-pilot said “(…) we haven’t got (*) approach (*)”. These words are extremely difficult to hear and it has not been possible to understand the entire sentence.

At 21 h 50 min 14 s, the Captain said “Fifteen hundred seventeen hundred it’s OK”, then five seconds later “(Sixteen) hundred, it’s OK”.

At 21 h 50 min 21 s, the Co-pilot asked the Captain, “You’re getting it back. Do you want me to put the approach on?”

At 21 h 50 min 45 s, the Captain announced “The approach is selected Loc and Glide”.

Between 21 h 50 min 52 s and 56 s, the Co-pilot on two occasions said: “(*) come right”.

At 21 h 50 min 58 s, the GPWS callout “Five hundred” is heard, followed by the “Glide slope” warning one second later.

At 21 h 51 min 02 s and 21 h 51 min 04 s, two GPWS “Sink rate” alarms are heard, the second occurring at the same time as autopilot disengagement.

Between 21 h 51 min 11 sec. and 21 h 51 min 14 s, four GPWS “Glide slope” warnings are heard. During this period, the Co-pilot on two occasions said “come right”.

At 21 h 51 min 15 s, the GPWS callout “One hundred” is heard.

At 21 h 51 min 16 s, the Co-pilot said “I've nothing in front”, then the Captain says “Go-around”.

At 21 h 51 min 21 s, the GPWS “Pull up” warning is heard.

The first noise of impact is heard at 21 h 51 min 22 s. The recording ends at 21 h 51 min 24 s.

1.11.3 FDR Analysis

The FDR was opened so as to access the protected module containing the memory. The external connector linked to the memory was intact. Decoding of the flight data parameters was carried out in accordance with Canadair document ref RAE-601R-210.

Various graphs obtained from readout of the data are shown in Appendix 4.

The following specific observations can be made:

The stopover in Nantes lasted about twenty-two minutes.

The pushback started at 21 h 09 min. Takeoff occurred at 21 h 16 min.

The climb-out was performed in manual control. The autopilot was activated at 21 h 24 min 46 s. as the aeroplane crossed flight level 200.

The cruise was performed at flight level 220, reached at 21 h 25 min 45 s.

At 21 h 27 min 53 s, the lateral heading mode was selected.

The descent began at 21 h 36 min 46 s; the cruise had lasted approximately eleven minutes.

At 21 h 41 min 07 s, the aeroplane passed flight level 115 on descent towards BODIL; its speed was 280 kt and the lateral navigation mode (FMS source) activated.

The flaps were extended eight degrees at 21 h 47 min 11 s. The aeroplane's speed was 180 kt.

At 21 h 48 min 06 s, the lateral heading mode was activated. The selected heading is 256°. Five seconds later, the 109.9 MHz frequency (ILS DME BG for runway 26 at Brest) activated on the left-side receiver.

At 21 h 48 min 16 s, the Captain changed his navigation source from FMS to VOR. The aeroplane, then 9 NM from BG, was on the Runway 26extended centreline.

The crew then configured the aeroplane for landing between 21 h 48 min 33 s and 21 h 49 min 30 s, extending the flaps to 20° and extending the landing gear. The aeroplane stabilized at 2,000 ft.

At 21 h 48 min 51 s, the deviation between the aeroplane position and the localizer beam centreline exceeded 0.25 point.

At 21 h 49 min, flaps were extended to 30° then 45°.

At 21 h 49 min 35 s, the aeroplane arrived at the GU marker beacon. Six seconds later, it crossed the glide path then passed above, while remaining in level flight.

At 21 h 49 min 58 s, the LOC deviation reached 2.5 points, which corresponded to the HSI limit display stop.

At 21 h 50 min 00 s, the altitude-capture vertical mode was active for one second. At 21 h 50 min 02 s, the vertical speed mode was active for five seconds. At 21 h 50 min 07 s, the altitude-capture vertical mode was active for three seconds. At 21 h 50 min 12 s, the vertical speed mode activated. The vertical deviation reached the maximum value of 2.1 points above the glide slope. The aeroplane started to descend.

Note: At 21 h 50 min 01 s, 21 h 50 min 10 s, and 21 h 50 min 11 s, none of the vertical modes recorded by the FDR were active.

At 21 h 50 min 05 s, the aeroplane passed the Outer Marker with the latter on the left beam (at 4.2 NM DME). The "marker passage" parameter remained inactive, which indicates that the aeroplane did not capture the Outer Marker signal. The crew therefore received no visual or aural indication of passing marker, which is confirmed by the CVR.

At 21 h 50 min 45 s, aeroplane passed through the glide path again. The deviation between the aeroplane position and the localizer beam centreline was at that moment 4.62 points; the aeroplane was at a height of 895 ft and an altitude of 1,256 feet. It would remain below the glide slope until it impacted the ground.

At 21 h 51 min 01 s, the aeroplane began to turn to the right, the magnetic heading going from 257° to 286°, the last value validated at the end of the recording, that is to say twenty-three seconds later. It was at that point 4.68 points off the centreline. At 21 h 51 min 04 s, at a height of 330 ft, the autopilot was disengaged. The aeroplane continued its turn to the right. Immediately after the AP disengagement,

the Captain applied nose-up input on the elevator trim tab. The aeroplane's pitch attitude, from being around -5° previously, increased to +0.6° at 21 h 51 min 11 s.

At 21 h 51 min 16 s, the QNH altitude of the aeroplane was 529 ft, the last value recorded above the decision altitude (520 ft). The radio altimeter indicated a height of 93 feet.

A thrust increase began at 21 h 51 min 16 s. The position of the elevator was then between 2° and 3° nose-up, the aeroplane’s pitch attitude was 0.7°, and airspeed was 120 kts. Between 21 h 51 min 19 s and 21 h 51 min 22 s, the moment corresponding to the first impact noise heard on the CVR, a nose-up action was recorded on the elevator (the position of the latter being between 8° and 9° at 21 h 51 min 22 s). During this time, the pitch attitude decreased to a value of - 5°.

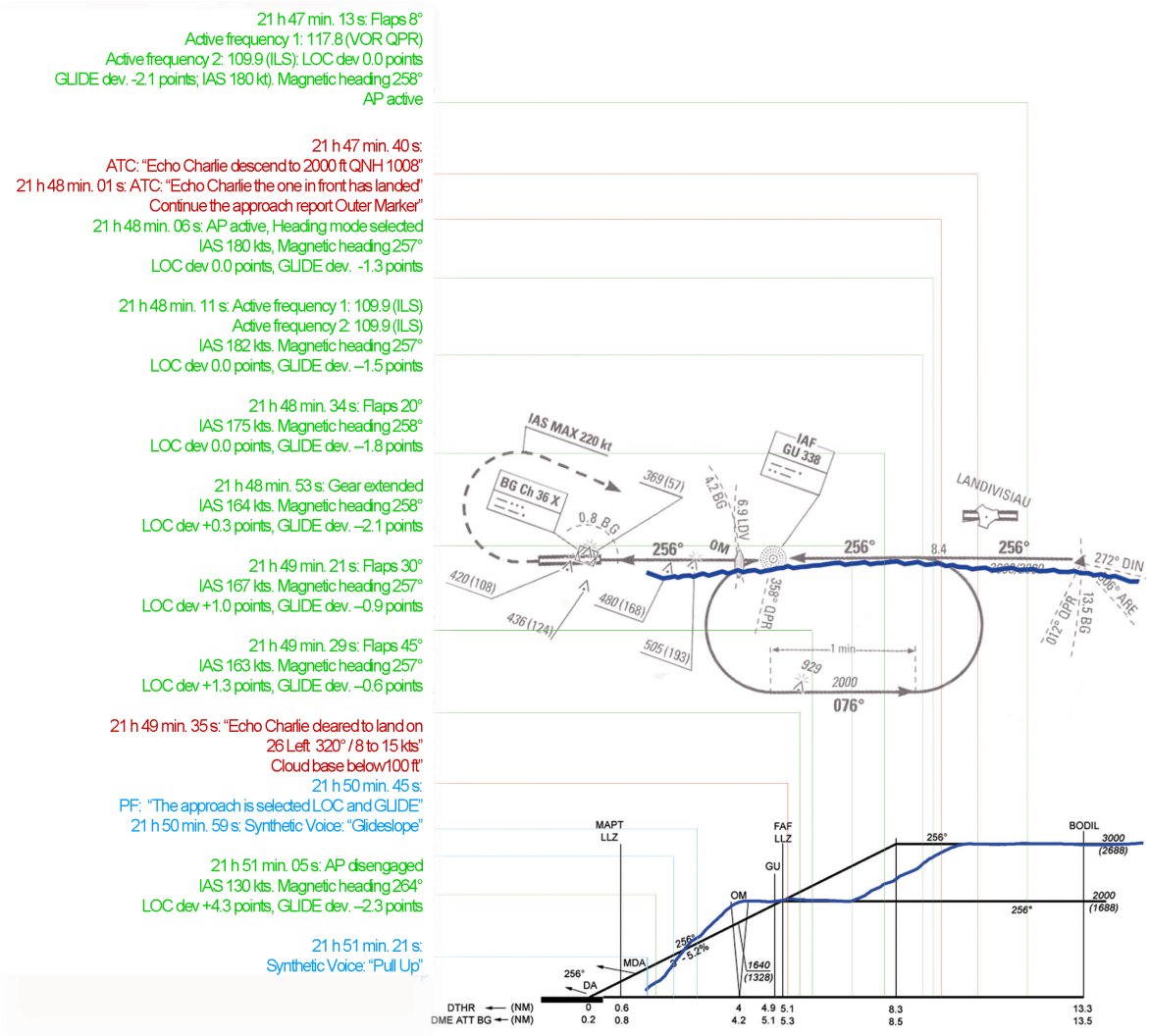
At 21 h 51 min 21 s, the HDG and VS modes de-activated, which corresponded to an action on the TOGA button.

The flaps and landing gear remained in the same configuration.

Note: The delay between an action on the FCP and its being recorded by the FDR corresponds to the information processing time (0.15 s maximum), and transmission times between the various components. The maximum time limit 1.45 sec, and the average, 0.75 sec.

1.11.4 Approach track

The following track was obtained, among other sources, from the recorded latitude, longitude and altitude parameters.

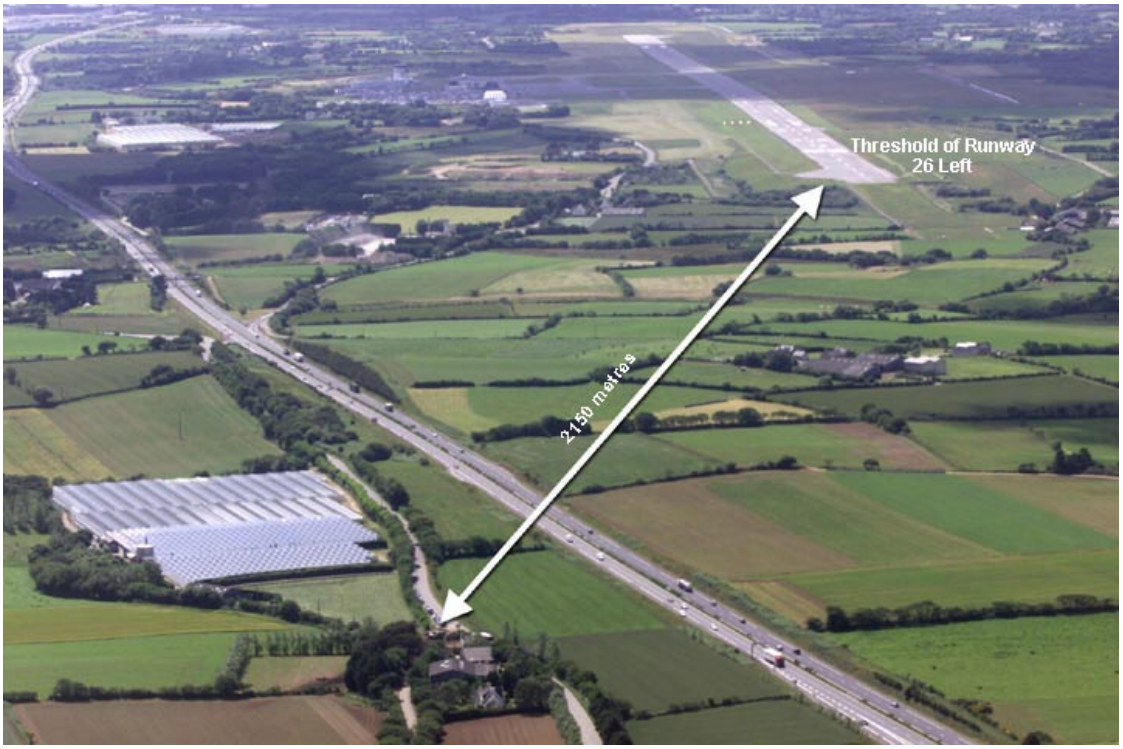


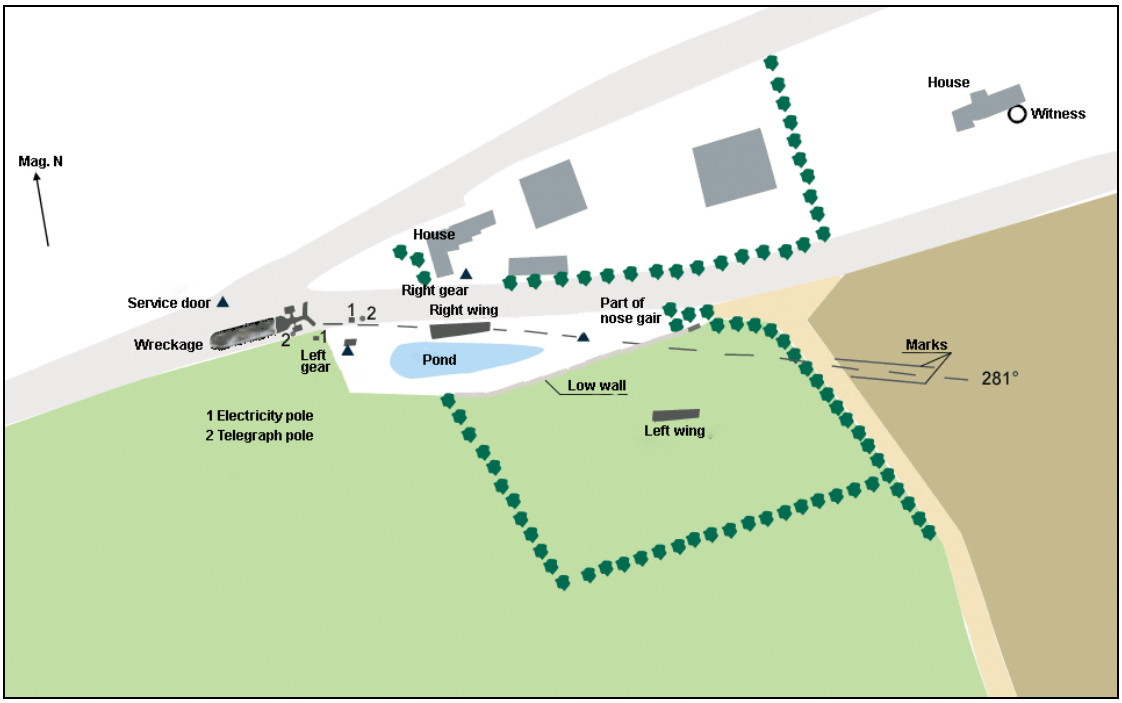
Note: The wind information presented in the preliminary report was obtained from the FDR and has been removed from the present diagram due to its lack of precision (see para. 1.16.1).

1.12 SITE AND WRECKAGE INFORMATION

1.12.1 Description of site

The accident occurred in the commune of Guipavas, at Kéritin, at a topographic altitude of one hundred and twelve meters (367 feet).





Wreckage distribution plan

First contact with the ground occurred in a mud field with a slight slope (about 3%). The main landing gear wheels left marks oriented along a 281° heading, without any marked furrowing, which indicates that the contact was not violent, with a low vertical speed.

Marks left by the main landing gear wheels

Thirty-four meters from the beginning of the marks left by the left main landing gear and forty-one meters from those left by the right main landing gear, the aeroplane struck a wooded embankment about one meter fifty high, oriented 45° to its path. On the embankment, the trees were cut off over a width of about twenty meters. In the middle of the damaged area, there were marks left by the two main landing gears. There were no marks attributable to the nose gear. The tip of the left wing, cut off at about one-third of span, was found about thirty-five meters from this point.

Wooded embankment

After the embankment, the aeroplane slid into a mown field. This was blackened by the fire. About fifty-five meters after the embankment, the aeroplane struck a stone wall about sixty centimetres high.

Stone wall

A few meters after the wall, some large trees were damaged. The tip of the right wing, cut off and with its winglet, was resting at the foot of a tree, about six meters from a shallow pond. The right wing, from the inboard flaps to the tip, was resting flat on the ground to the right of the pond in relation to the aeroplane's general path.

The left wing root and the left landing gear were on the other side of the pond, at the foot of a large tree, damaged. The inboard flaps were turned over but still attached to their hinges.

The main wreckage was flat on the edge of a road. Apart from the aft section, the rest of the fuselage, from cockpit to aft pressure bulkhead, had been destroyed by fire. The nose gear was lying flat under the debris.

The right landing gear was cut off at the level of the main oleo strut and the end of the wing-side actuating cylinder. It was on the edge of the road, about fifteen meters from the right wing.

Wreckage

On the left side of the road, two poles, one pine and the other in reinforced concrete, were lying flat. About thirty meters further on, there was debris from a second reinforced-concrete pole and another pine pole, damaged and leaning over, in contact with the left engine air intake.

The forward right service door was about fifteen meters from the right side of the aeroplane's nose.

1.12.2 Description of Wreckage

The leading edge of the left wing bore several curved indentations. The outer flap was only attached by the joint of the outer hinge. The screwjack rods of the mechanical flap actuators were extended by about 115 mm, which corresponds to a position close to 45°.

The right wing showed marks that were shallower than those observed on the left wing. The wing root was destroyed by the fire. The outer flaps, still connected to their hinges, were extended to 45°. The two inner flaps, separated from the wing, had been destroyed by the fire.

Forward right service door

The forward right service door, still attached to its frame, was partially cut off in the upper quarter. The handle was in the locked position. The tumblers and the control mechanism operated when the handle was moved. The door showed no traces of fire.

Forward right service door

Fuselage

The cabin, back to the aft pressure bulkhead, had been destroyed by the fire, with the exception of some instrument panels, flight controls and computers. No elements of the roof section were found.

The front left of the aeroplane's nose bore marks of an impact with the trunk of a large tree. Wood debris had been trapped in the distorted sheet metal.

The instrument panel was broken into two parts. Despite the damage, it was noted that:

- the right engine fuel shut-off valve had been activated: the transparent cover was down;
- the left engine fuel shut-off valve had been activated, the transparent cover had disappeared.

The backup altimeter was found set on 1009 hPa.

Note: the backup altimeter and main altimeters were in all probability set at 1008 hPa before impact, as indicated from analysis of the CVR at 21 h 39 min 55 s.

The landing gear control was found in the "extend" position. The flaps control was found damaged, with free movement, in an intermediate position between "retracted" and the first detent.

The engine control quadrant was destroyed. No useful position of the throttles could be observed.

A certain number of documents associated with the flight were found in the front of the wreckage, in particular the landing card giving the landing reference speed (Vref) used by the crew, showing 132 knots.

The passenger access door, located forward on the left, was in place in its frame, with the handle in the locked position. It had been destroyed by the fire. The emergency exit over the right wing, burnt, had come slightly out of its frame. The emergency exit on the left wing was not found in the debris, the part of the aeroplane where it was situated having been destroyed by fire.

The aft part of the fuselage was lightly damaged. Both engines and the horizontal stabilizer were still in place. The tips of the right and left horizontal stabilizer and of the elevator were damaged.

Both engine fire-extinguishing bottles were in place. The bottle for the right engine was empty, with the indicator on 0. The bottle for the left engine was still under pressure, the pressure-gauge needle being in the green zone.

The emergency beacon was in place, on its receptacle.

Engines

The left engine air intake bore marks of an impact with a hard object, and contained concrete debris. About a third of the fan blades were broken off at the level of the blade roots, which indicates a bending moment in the opposite direction to normal rotation. The blades still in place were bent back in the opposite direction to rotation. The inner sides of the cowlings and casings were blackened by fire. The engine core showed no signs of pre-impact damage. The MFCU fuel feed line was in the closed position.

The right engine air intake bore marks of multiple impacts with trees, and contained wood debris, branches and chewed leaves. The cone had broken off at its attachments to the first-stage disk. About one-third of the fan blades were broken off at the level of the blade roots. The blades still in place were bent back in the opposite direction to rotation. The inner sides the cowlings and casings were in good condition, with no appreciable traces of soot or smoke. The engine core showed no signs of pre-impact damage. The MFCU fuel feed line was in the closed position.

1.13 Medical and Pathological Information

The Captain had trauma injuries caused by the impact. These injuries were sufficiently serious to cause instantaneous death. The autopsy revealed no condition prior to impact that would have led to any form of incapacity.

1.14 Fire

On first contact with the ground, the aeroplane had about one thousand eight hundred kilos of fuel on board, distributed in the wings, the centre tank being empty.

Observations made on the ground, and the witness testimony, indicated that the fuel caught fire when the aeroplane lost a part of its left wing after striking the wooded embankment. During the aeroplane's run along the ground, the fire remained localized outside the fuselage.

When the aeroplane came to a stop, the fire was intense outside the fuselage around the central and rear sections, more so on the left than on the right. Some small pockets of fire broke out inside the passenger cabin, along the sidewall.

About one minute later, the fire had increased in intensity inside the aeroplane.

When the rescue services arrived at the scene, twenty-seven minutes after the accident, the cockpit and the cabin, completely destroyed, were still on fire. The horizontal stabilizer and the engines did not suffer from significant fire. The fire in the aeroplane and in the surrounding vegetation was quickly brought under control by the fire-fighters, equipped with foam-spraying vehicles.

1.15 Survival Aspects

1.15.1 Organisation of Rescue

The aerodrome fire-fighters were alerted at 21 h 53 (that is, two minutes after the accident) by the control tower, which informed them that radio and radar contact with the aeroplane had been lost in the area of the GU beacon.

At 21 h 55, the fire crews started searching in the aerodrome area, on the runway 26 Left extended centreline. They were severely hampered by thick fog limiting visibility to about twenty meters in places.

At 21 h 56, the control tower alerted the city of Brest fire service.

At 21 h 57, the CODIS received a call from a passenger by cell phone.

At 22 h 03, the site of the accident was identified by the CODIS as "Kérintin" and the emergency services were sent there.

The first Brest city fire service vehicle arrived at 22 h 18. At around 22 h 25, this vehicle was joined by the other Brest vehicles (city and aerodrome).

No emergency beacon signal was received by Brest ATC or the Toulouse detection centre (SARSAT).

1.15.2 Occupant Survival

1.15.2.1 Impact

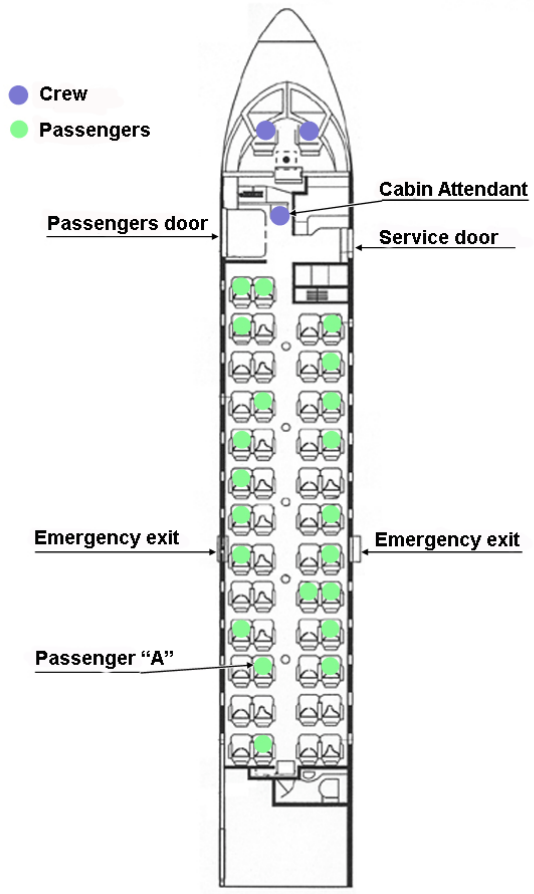
All of the testimonies show that after an initial and rather heavy impact the passengers, who were all seated and strapped in, were thrown forwards. The deceleration of the aeroplane was progressive, accompanied by slight shaking. The aeroplane caught fire about forty meters after the landing gear touched down, but the inside of the cabin was spared the fire until the aeroplane came to a stop.

The passengers remained in their seats until the aeroplane came to a complete stop.

The cockpit suffered severe damage following successive frontal impacts with the various obstacles. The fuselage, however, was little damaged. Only the service door was torn off.

1.15.2.2 Evacuation

The location of the passengers in the aeroplane is shown in the following illustration:



Location of passengers in cabin

After the aeroplane came to a stop, the Flight Attendant opened the cockpit door and saw serious damage, in particular several large hull breaches. She then asked the passengers to leave via the opening left by the torn-off service door, and stood-to near the latter in order to assist the evacuation.

The passengers in the front rows heard the announcement and evacuated. The other passengers mostly also moved towards the front. Since a certain number of oxygen masks had dropped down, one passenger in the cabin mid-section had put on his mask and remained seated until another passenger told him to get out. Two other passengers had moved to the aft of the cabin, until a passenger in the last row told them that there was no emergency exit there. In addition one passenger (A), a regular flyer, opened the left emergency exit. He saw a lot of flames through the opening and let go of the door. Seeing that evacuation of the aeroplane was possible via the front he went in that direction. The flames began to enter through the open emergency door.

Note: Information concerning opening of emergency exit doors – either written or verbal – does not alert passengers to the risks of premature opening. Certain operators have introduced pictograms into their safety instructions for this purpose.

Given the advancing fire, the Flight Attendant exited the aeroplane and continued to assist the passengers from the outside. The Co-pilot exited the flight deck through the hull breaches. He moved away from the aeroplane and was assisted by the Flight Attendant.

The last passengers to evacuate the aeroplane were hampered by the smoke that had enveloped the cabin, and had to get down in order to breathe. Some of them covered the last few meters while holding their breath.

Lighting conditions were good due to the cabin lighting and the external fire. This allowed the passengers to find their way and move forward without difficulty. The cabin floor was about fifty centimetres from the ground. The evacuation was completed in less than a minute, calmly and with no pushing.

1.15.2.3 The wait for rescue

Once outside, the aeroplane’s occupants moved away and grouped together on the road, under the direction of the Flight Attendant. All were all suffering from slight back pains but were able to move. The only survivors who needed to lie down were the Co-pilot, with a head injury, and one passenger with a broken arm.

The occupant of a nearby farm arrived quickly with an extinguisher and tried to put out the fire, without success, given the latter's intensity. Some of the passengers and the Flight Attendant contacted the emergency services or their families by cell phone. They had initial difficulties with the emergency services regarding their messages not being taken seriously.

During the time spent waiting for the emergency services to arrive, numerous discussions took place between the passengers, some of whom considered going to seek help themselves, while others wanted to go directly to the airport.

1.15.2.4 Intervention of emergency services

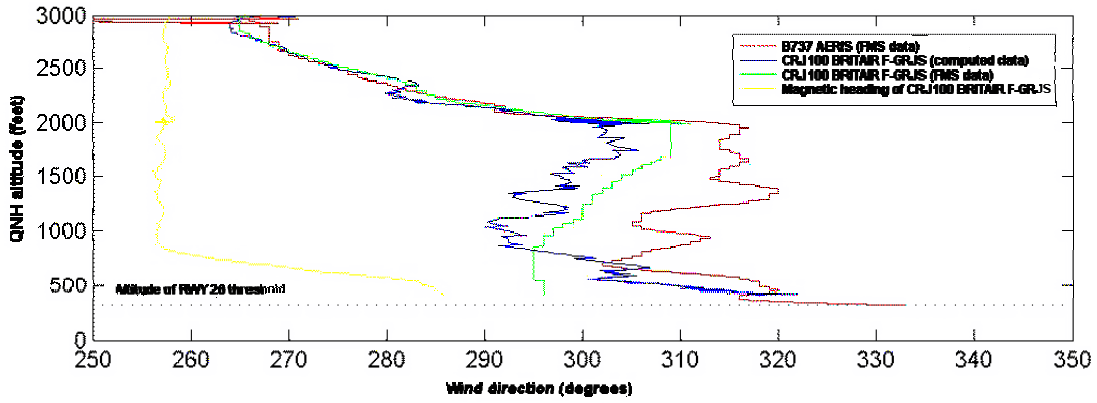
When the first rescue vehicle arrived, one of the fire-fighters took care of the survivors while the others began to put out the fire. The emergency medical service (SAMU) then arrived approximately ten minutes later. The Co-pilot and two passengers were evacuated to hospital in Brest. The other survivors were taken to the airport terminal by minibus, where they were examined by a doctor. Some were later hospitalised.

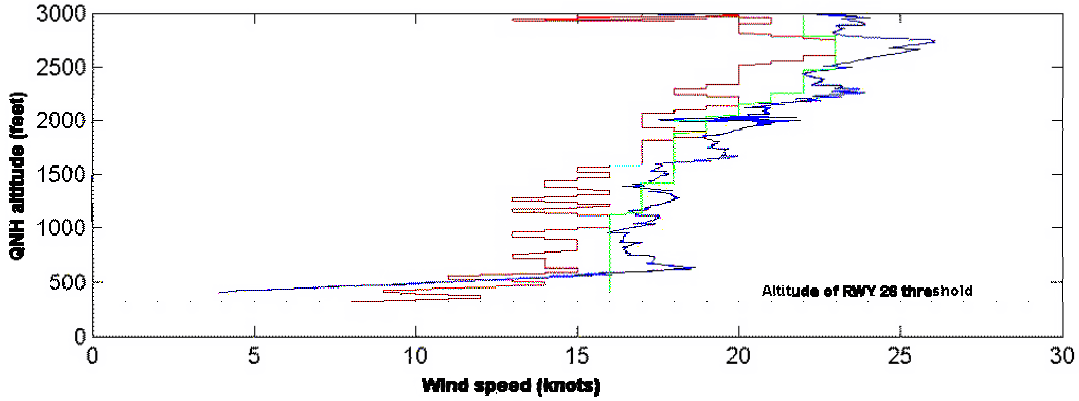
1.16 Tests and Research

1.16.1 Calculations of Wind Characteristics

The wind parameters (intensity and direction), recorded every four seconds, show relative stability below three thousand feet. The CRJ-100 FMS uses different calculation and filtering methods to determine the intensity and direction of wind, depending on the navigation mode of the aeroplane. However, since F-GRJS was not fitted with a GPS, calculation precision was not good. The investigators therefore recalculated the intensity and direction of wind from other recorded parameters (ground speed, pressure altitude, drift etc.).

The results of these calculations were compared with the other available recordings (FDR of the previous aeroplane and meteorological sounding balloon released above the aerodrome at 00 h 00, or around two hours after the accident). They are represented on the following diagrams:





The various sources, despite some disparities, show that a wind rate was present between one thousand feet and the ground: the wind force went from a value of between 15 and 20 knots, to a value between 5 and 10 knots, and the wind direction was veering from west to north.

1.16.2 Inspection of Aeroplane Equipment

1.16.2.1 Flaps

The positions of the flap control screwjacks were checked and measured. These jacks were all in the fully extended position, which corresponds to a flaps-down position of 45°, coherent with the data retrieved from the FDR at the end of the recording.

1.16.2.2 Flight control panel

During inspection of the FCP at the crash site, the fuel cutoff switches for the left and right engines, and the activation switch for the right engine extinguisher, were recovered in pulled condition. The surviving pilot and the various work teams at the accident site (firemen and SAMU) did not remember having pulled these controls. It was therefore suggested that the Research Unit of the Air Transport Police search for possible fingerprints on these pushbuttons.

The use of fingerprinting powder produced no useful evidence. However, traces of various liquids were observed, including extinguishing products used by the fire-fighters. These products could have contributed to the destruction of any fingerprints.

1.16.2.3 Pitch control system

1.16.2.3.1 Visual inspections

The worm gear on the horizontal stabilizer showed no signs of damage or incorrect installation. The distance between the attach points was between 207 and 209 mm; these values correspond to an angle of incidence of between -4.48° and -4.62° for the horizontal stabilizer, which is coherent with the value of the parameters at the end of the recording.

The artificial control-feel system showed no signs of damage or incorrect installation: the two linear jacks were in the same position, between 238 and 239 mm; these values are coherent with those of the parameters at the end of the recording.

The elevators showed no signs of damage or incorrect installation.

1.16.2.3.2 Workshop inspections

The PFSU, the MCU, the HSTA, the primary servo and the mount servo were workshop-inspected in the presence of the investigators. These inspections showed that these systems were compliant with specifications.

1.16.2.4 Emergency beacon

Until the FDR stopped recording, the accelerations to which the aeroplane was subjected along the longitudinal axis were less than 1 g, which is the selected value for triggering the emergency beacon. Since the aeroplane continued to slide along the ground after the end of the recording, it is not possible to determine whether it underwent longitudinal accelerations greater than 1 g.

Note: It should be noted that the beacon triggering sensor is positioned so as to detect longitudinal accelerations only, and that the signal is triggered automatically according to a combination of coupled inputs - longitudinal acceleration and acceleration-duration. The triggering curves associated with these two parameters are shown in Appendix 5.

The various components retrieved were visually inspected: the selector situated on the beacon was set at "AUTO", in compliance with procedures, and the connection cable to the antenna was in good condition. It was not possible to examine the electrical circuit, the antenna, the electronics unit in the equipment bay, nor the control unit in the cockpit, since they had all been destroyed in the fire.

In order to determine whether the beacon would have functioned for longitudinal-acceleration values of greater than 1 g, the investigators proceeded with a real transmission test of the beacon, followed by a teardown inspection performed by the manufacturer. The findings were that the beacon, when subjected to a high acceleration, transmitted the correct distress signal, but that it did not function for the acceleration values stated in the specifications. The error was significant; it could not be established which of the circuit boards was faulty (sensor or G-switch).

Note: The voltages supplied by the battery packs of the radio and G-switch PCB's were to spec, but the battery pack validity dates (December 2002 and March 2003 respectively) had expired.

1.16.2.5 Electronics units

Electronics units containing non-volatile memory can store information not recorded in the FDR (such as desired clearance path, programmed holding pattern etc.). The investigators therefore had the two Air Data Computers (ADC), the Maintenance Diagnostic Computer (MDC) and the two Flight Management Computers (FMC) inspected by the manufacturer (Rockwell Collins). Given the heavy damage inflicted by fire, no relevant information could be extracted from this equipment.

1.16.3 Flight Simulator Research

On 19 November, 2003, the BEA organized a work session on the CRJ-100 flight simulator at the ICARE training centre. The sessions took place with the cooperation of two CRJ-100 instructor-captains.

Four scenarios were prepared and run. The session was filmed by the flight-simulator stationary camera, which provided a general view of the cockpit. A view of the EFIS was obtained through a portable camera.

The purpose of the session was, essentially, to observe the following points:

- the MFD displays, notably, reproduction of the holding pattern;
- mode-changes on the FMA; behaviour of the flight director and more generally of the PFD;
- transition from NAV mode to APPR mode, and associated actions;
- arming of the APPR mode inside and outside of LOC beam capture, and also interception of the LOC and the glide slope by the APPR mode;
- behaviour of the flight simulator in go-around mode (flaps 8°) and during an obstacle-avoidance manoeuvre (flaps 45°) - control forces, loss of altitude;
- the operating logic of the GPWS alarms.

The four scenarios as well as the research results are described in Appendix 6. The following was shown:

- interception of the LOC and glide by the APPR mode took place in accordance with the manufacturer's specifications;
- the GPWS announcements transmitted by the simulator were not completely representative of the aural warnings heard in flight in the aeroplane; in particular, the “Minima” warning is heard regardless of whether the crew displays a minimum decision height or altitude;
- go-arounds or obstacle-avoidance manoeuvres performed at ninety feet radio-altimeter height, with engine thrust close to that recorded at the beginning of the go-around, were performed without impacting the ground;
- the simulator did not faithfully reproduce the flight-control inputs (notably during go-arounds).

Note: It was not possible to program the simulator for a wind that changes direction from left to right while the aeroplane is in descent (this type of wind-change occurs seldom, but it was the case on the day of the accident).

1.16.4 Behaviour of the CRJ-100 on Go-around

1.16.4.1 General characteristics

According to information from Bombardier, the CRJ-100 configuration and pilot actions required for a standard go-around, when the aeroplane is at Vref and under engine thrust of 60 to 70% of N1 (corresponding to a 45° flaps-down approach on a glide slope of 3°), are the following:

- the pilot's first action must be to pull back on the control column to bring the aeroplane nose-up;
- this requires applying a force of about 25 to 30 lbs (11.3 to 13.6 kg) on the control column and the elevator deflection must be increased by 6° in less than one second;

- the throttle input must take place within one second of the control column input;
- maximum thrust is attained in less than three seconds;
- the nose-up pitch moment induced by the elevator is about three times greater than the nose-down moment induced by the engine power increase;
- flap-retraction should occur shortly after the increase in engine speed, when the aeroplane starts to climb; retraction is accompanied by a loss of lift and a nose-up moment, leading to a slight and momentary loss of altitude;
- the loss of altitude is about twenty-five feet after the initial control column input;
- the aeroplane attitude constantly increases during the go-around.

Note: The pitch moment due to engine thrust has two components, namely:

- the net engine thrust, which induces a nose-down pitching moment,
- an aerodynamic moment resulting from the effect of the engine blast on the horizontal stabilizer and wings, which induces a nose-up moment.
- The consequence is a nose-down moment during engine power increase.

1.16.4.2 Behaviour of the CRJ-700 on go-around

Bombardier has stated that to obtain the same standard go-around performance on a CRJ-700:

- the pilot must apply a force of about 30 lbs (13.6 kg) on the control column;
- the elevator deflection must increase by 7° in three seconds.

The conclusion is that in standard conditions, pulling action on the control column must be faster on the CRJ-100 than on the CRJ-700.

1.16.4.3 Last go-arounds performed at Brit Air

To complete the above data, the investigators asked the Flight Safety Analysis Department of Brit Air to provide the parameters for the last five go-arounds (or obstacle-avoidance manoeuvres) (flaps 45°), performed on CRJ-100 by the carrier's pilots.

The following table gives the engine speeds prior to go-around, and the observed loss of altitude:

Go-around	N1, engine #1	N1, engine #2	Altitude-loss (ft)
1	60	60	15
2	53	61	0
3	28	37	100 *
4	65	65	32
5	54	69	16

* The hundred-foot altitude-loss occurred during conditions involving a steep wind rate.

1.16.5 Bombardier Simulation of Aeroplane Behaviour prior to Accident

1.16.5.1 Method

At the request of the investigators, and, in order to study the behaviour of the aeroplane during go-around, Bombardier undertook a detailed analysis of the last fifty seconds of the flight. The purpose was to compare the data obtained from the accident flight, against the results of a simulation obtained on a digital model representing a nominal CRJ-100 ("Bombardier Level D flight simulation mathematical model"). The work was undertaken using data from the BEA Preliminary Report, and a document entitled "Minimum Approach Break-Off Height (MABH) for HGS Certification".

The analysis showed that, in order to make the flight parameters of F-GRJS correspond to those of the simulation, it was necessary to introduce a wind rate below 570 feet QNH, and increase the aeroplane weight used for the simulation from 17,940 kg to 18,852 kg, that is, an increase of about 5%.

Note: The analytical work performed on the parameters (see para. 1.16.1) confirmed the presence of a wind rate close to that identified by Bombardier.

The investigators then asked Bombardier which factors could explain the presence of a possible additional weight for the accident flight. Bombardier analysed the FDR data of the seven flights preceding the accident flight, and observed that these flights also required the addition of a certain extra weight in order to make the parameters of the "nominal" aeroplane correspond to those of F-GRJS. However, the actual additional weight values required varied according to the flight, and presented no obvious correlation. Bombardier stated that following recording of data on a test aeroplane for the purposes of comparison with the digital model, weight differences again appeared. For Bombardier, these differences may not be attributable to a single criterion, but are probably the result of stacking of small calculation errors in the digital model, and errors in calculating the fuel consumption or determining the aeroplane weight at takeoff [(7)].

1.16.5.2 The go-around

Bombardier has stated that the amplitude of the engine thrust variation (from 45% of N1 to 90% of N1) between 80 ft and 50 ft was far greater than that for a normal go-around (from 65% of N1 to 90% of N1). Given the airspeed at go-around (about 115 knots), the nose-down pitching moment produced by the increased engine thrust is equivalent to a variation of 6° in elevator deflection. The pitch moment induced by the elevator and that induced by the increased engine thrust were therefore equal and opposite, thus cancelling each other out.

Bombardier also stated that at 115 knots, the efficiency of the elevator is reduced by about 25%.

[(7)] The Bombardier memos can be consulted on the BEA Website.

Bombardier determined that the aeroplane as configured in the last seconds of flight would have stalled at a speed of 103 knots.

1.16.5.3 Influence of certain parameters on last seconds of flight

Bombardier produced simulations using the digital model and the increased weight factors, the purpose being to modify certain flight parameters in order to evaluate their respective influence on the last seconds of flight.

Modified parameter	Method	Output data
Wind rate	The wind rate is replaced below 150 ft by a two-knot headwind component.	Airspeed drops to 120 kts. The flight path is less curved. The aeroplane is 50 to 60 ft above ground level at the point of impact, in almost horizontal flight.
Elevator control inputs as recommended	The elevators begin to move one second prior to application of go-around thrust. The elevator deflection increases six degrees in one second.	The maximum aeroplane attitude increases by 4° to 5°. The flight path gradient is lower. At the level of the point of impact, the aeroplane is twenty feet AGL and thereafter descends on a slight gradient to ground. Note: the result can be explained by the loss of elevator efficiency due to the low airspeed.
Flap inputs	The pilot retracts the flaps at the same time as applying power	The loss of lift leads to slightly earlier ground contact
Simultaneous variation of all parameters presented above		The minimum airspeed is 120 kts. The flight path is less curved. The aeroplane clears the ground by 100 ft, with an upward flight path.
Action on elevator controls as recommended but with greater amplitude.	The elevators begin to move one second prior to application of go-around thrust. The elevator deflection increases ten degrees in two seconds.	The aeroplane does not touch the ground. At the level of the point of impact, A/C is 50 ft AGL; this is the lowest point of the flight path. The attitude reaches a value close to that required to trigger the stick shaker.

1.16.6 Ground Proximity Warning System (GPWS)

In order to check correct operation of the GPWS, the investigators asked Honeywell to conduct simulations based on the FDR data. These simulations were conducted using a GPWS similar to the one onboard the aeroplane ("Mark 5 GPWS"), then using a new-generation GPWS model featuring a stored digital terrain model (Honeywell "EGPWS").

The simulation with the Mark 5 GPWS generated a sequence of aural announcements close to that retrieved from the CVR recording.

Time	Radio altimeter height	CVR	Simulation
21 h 50 min 58 s	486	500	500
21 h 50 min 59 s	482	Glideslope	Glideslope
21 h 51 min 02 s	381	Sinkrate x 2	Sinkrate x 2
21 h 51 min 05 s	291	300	
21 h 51 min 06 s	291	-	Pull up
21 h 51 min 07 s	234	Glideslope	Glideslope
21 h 51 min 08 s	210	Glideslope x 6	
21 h 51 min 09 s		-	200 - Glideslope x 5
21 h 51 min 15 s	107	100	
21 h 51 min 16 s	93		100 - Glideslope x 3
21 h 51 min 20 s	50	Sinkrate	50
21 h 51 min 21 s	32	Pull up	40
21 h 51 min 22 s	19		Pull up

Note: The differences between the simulated alarms and those recorded in the CVR, notably the “Pull up” alarm fifteen seconds before impact with the ground, are due to the imprecision of the simulation resulting from sampling of the FDR parameters.

During the simulation with the EGPWS, a “Too Low Terrain” alert, repeated four times, is heard fifteen seconds before impact.

1.16.7 MSAW Simulation (Minimum Safe Altitude Warning)

1.16.7.1 General

The MSAW ground system is a predictive software for detecting potential conflicts with terrain. If the predicted flight path of an aeroplane exceeds the authorised manoeuvring envelope, and if the software detects the possibility of collision with terrain, an audible and visual alarm is transmitted to the controller.

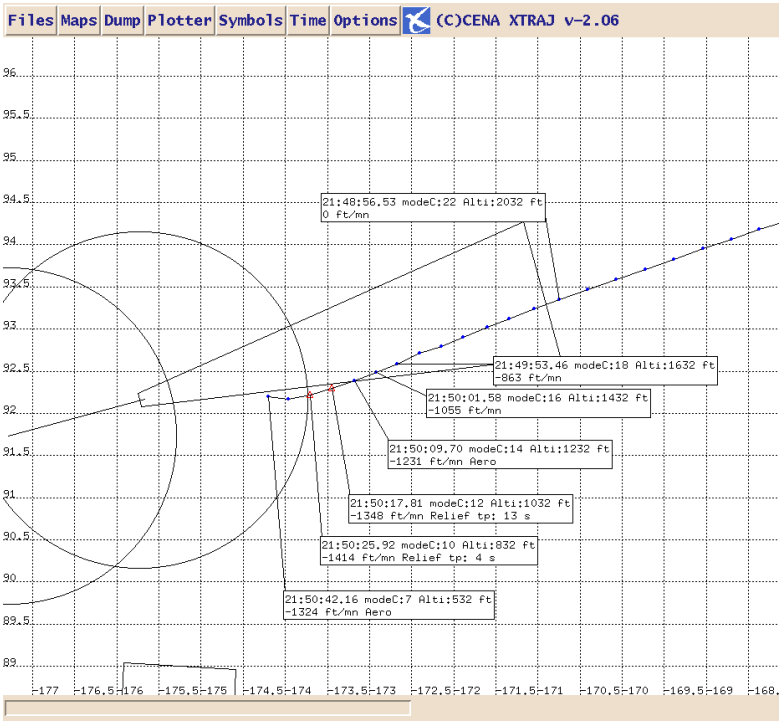
Note: The authorised manoeuvring envelope is defined on a standard basis but may be configured according to the specificities of the airport.

At the time of the accident, the MSAW system was installed on airports at Lyons, Marseilles, Paris-Orly, Montpellier, Basel-Mulhouse and Strasbourg; it was under test at Paris Charles de Gaulle, Nice and Fort-de-France; it was also under consideration for Nantes, Biarritz, Tarbes, Ajaccio, Bastia and Pointe-à-Pitre airports.

1.16.7.2 Simulation of accident flight

At the request of the investigators, the DGAC ATC Research Centre performed a simulated MSAW session using the radar recording supplied by the Regional Air Traffic Control Centre ("CRNA Ouest"), and data from the FDR.

This simulation showed that the system would have detected that the aeroplane was outside its authorised envelope at 21 h 50 min 53 s. Since the display renewal rate of the radar processing system is asynchronous with the Regional Traffic Control Centre radar, a period of three to eleven seconds is required before the alarm is effectively transmitted to the controller. Thus, the latter would have had a MSAW alarm between 21 h 50 min 57 s and 21 h 51 min 05 s, that is sixteen to twenty-four seconds before the aeroplane touched the ground. It would then be necessary to allow for the controller's reaction time, transmission of the alert message to the crew, and the reaction times of the latter and the aeroplane.



Note: The radar time reference precedes that of the FDR by thirty-six seconds.

1.16.8 Cockpit Ergonomics

1.16.8.1 Display of localizer and glide information

1.16.8.1.1 Regulations

The regulations concerning the ergonomics of ILS displays are contained in JAR 25 (1329) for normal and Cat-I precision approaches and in JAR 25 and AWO for Cat II and III precision approaches. The options selected by Bombardier and Rockwell Collins for the CRJ-100 meet the certification regulations.

1.16.8.1.2 Display on the PFD

When an ILS frequency is selected by one of pilots and the chosen navigation source is VOR, any deviations from the glide path and/or the localizer beam centreline are displayed on this pilot’s PFD.

Glide slope information is displayed on the right-hand side of the ADI by a cyan coloured diamond on a vertical scale graduated in points from -2.5 to 2.5 points. A cyan-coloured triangle appears at the upper or lower limit of the scale if the deviation exceeds these values.

Localizer Information is displayed on the HSI by a green-coloured vertical segment on a horizontal scale graduated in points from -2.5 to 2.5 points. When the height of the aeroplane is less than six hundred feet AGL, a dilated representation of the localizer appears in the bottom of the ADI, in the form of a cyan-coloured diamond.

Note: the CRJ-100 is not the only aeroplane for which this information is displayed separately but on the same screen.

1.16.8.1.3 Other displays

A representation of ILS information on one and the same instrument is available on the HGS and on certain functions of the MD. On approach, Brit Air pilots generally use the MAP mode that provides a representation of the geographical position of the aeroplane but no representation of ILS information, using the HGS for Category III precision approaches.

1.16.8.2 Adjustment of pilots' seats

To ensure that pilots see all displayed information, Bombardier recommends that seats be adjusted so that the spherical indicators situated in the overhead cockpit panels are seen as aligned.

Transport Canada indicates that the HSI may be partially concealed by the control column if the seat is adjusted too low or too far back; when the seat is adjusted too high or too far forward, the FMA may be concealed partially by the lighting glare shield.

Several pilots have reported that the recommended position for them seemed relatively uncomfortable and “high”, concealing the first line of text on the EICAS, and that they preferred to lower their seats slightly. Transport Canada stated that many pilots adopt the low position, which conceals between ten and twenty percent of the HSI.

The Co-pilot indicated in his testimony that since he was PNF on that leg, he had pushed his seat back slightly in relation to the recommended position, in order to have a more general view of the cockpit. The control column did conceal the lower part of the HSI but he could see the localizer deviation indicator.

It was not possible to determine the Captain's seat adjustment.

1.17 Information on Organizations and Management

1.17.1 The Operator

1.17.1.1 Structure

Brit Air, based in Morlaix (Finisterre department), was founded in 1973 and became a wholly owned subsidiary of Air France in April 2001. It serves forty destinations in France and Europe, with a fleet of thirty-eight aeroplanes: eight Fokker 100’s, twenty CRJ-100’s and ten CRJ-700’s.

Brit Air employs 367 flight crew and 294 cabin crew, who operate out of seven bases: Lyons (approximately one-half), Paris, Rennes, Nantes, Brest (home to 22 flight crew), Strasbourg and Nice.

1.17.1.2 Flight Safety Analysis Department (SASV)

SASV, the Flight Safety Analysis Department of Brit Air, was created in 1998 and has reported to the General Management since April 2003. Previously, it reported to the Quality Management. At the time of the accident, it was based at Morlaix, in the building occupied by Icare. In January 2004 the department moved into the building occupied by the medical department.

SASV employs eight people, full-time or part-time. Its role is to collect and circulate all information likely to improve flight safety.

In 2002, 850 Flight Safety Reports and 227 Cabin Safety Reports were submitted to SASV, for investigation and storing in a anonymous database. In parallel, 85% of flights are analysed automatically, any anomalies detected being archived by aeroplane registration.

The SASV produces a quarterly statistical-analysis report. Three times a year it publishes a brochure ("Ciel Clair") summarizing the reports covered, and containing partial statistical analyses. A Flight Safety Bulletin ("BSV") is produced once a year. A BSV mainly devoted to CFIT was produced in November 2001.

Note: Safety bulletins from other operators’ flights (between 180 and 200) are also available; they can also be consulted in a library located within the Department.

SASV holds a quarterly meeting with the managers and trainers involved with flight crew. The purpose of this meeting is to inform the various players of feedback received, any requirements regarding modification of procedures, or other training needs (see para. 1.17.2.1.2).

Examination of the flight analysis files showed that proportionally few non-stabilized approaches resulted in crew reports.

1.17.1.3 Oversight authority

Brit Air is monitored by the “Direction de l’Aviation Civile Ouest” in Brest. The organization has a specialized air transport division staffed by six persons: three engineers and three senior technicians (operations controllers).

The last document-based operations check, performed in the framework of renewal of the carrier’s Air Transport License, took place from 19 to 24 March 2003. It concluded that the operator “had made vigorous efforts to comply with the OPS 1 regulations”. Certain minor anomalies were detected during this period, and consequently the civil aviation authority (DAC Ouest) renewed the Air Transport License in 2003 for a period of two years.

Note:

- None of the anomalies detected had any bearing on the circumstances of the accident.
- Among the points raised, the authority had accepted attachment of SASV to Quality Management.

In addition, the DGAC flight inspection organization undertakes spot checks in flight and on simulators, about five times per year for Brit Air. The last in-flight checks prior to the accident nevertheless dated from October 2002. They had not raised any significant issues.

1.17.1.4 Relations with Air France

Although flight marketing is carried out by Air France, Brit Air is in charge of operations and is therefore independent in terms of aeroplane scheduling procedures, work methods and training. Within the framework of the DGAC circular relating to the supervision of charter airlines, Air France performs a follow-up visit every two years, with three Auditors -- a captain, a maintenance specialist and a ground-operations specialist. The last visit took place on 26 March 2003. The follow-up mission report concluded: “Brit Air is in accordance with the JAR requirements. The company's Quality system is efficient. Very satisfactory visit”.

Note: Attachment of SASV to the Quality Management is noted in the follow-up mission report.

1.17.2 Training of Flight Personnel

1.17.2.1 Flight crews

1.17.2.1.1 General

Training and practice for flight crew is performed by Icare, a training organization (TRTO) belonging to Brit Air, in compliance with OPS1 and FCL orders. Icare was set up in 1991 and effectively became independent of Brit Air in 1999. Instructors are designated from a list accepted by Brit Air, and are validated by SFACT. They also operate as active flight crews at Brit Air, with the exception of certain SFI's.

1.17.2.1.2 Practice and recurrent checks

The person in charge of training at Brit Air establishes a three-year practice and periodic-checking program in cooperation with the section heads and the SASV department. This program, known as "ECP" in French, is submitted annually for approval by the civil aviation authority ("Direction de l'Aviation Civile Ouest"), and the aeronautical training authority ("Service de la Formation Aeronautique et du Contrôle Technique").

Brit Air delivers training modules and performs periodic checks of flight crew during two yearly courses, called "OPS 1" and "OPS 1 and FCL", which include simulator sessions performed on the CRJ-700 and 100 respectively. The two courses are separated by six months on average. In addition, pilots undergo an annual check flight.

Note:

- Training on precision approaches takes place during the OPS 1 training course, and the checks associated with these approaches are performed during both courses.
- The training program does not cover awareness-training relating to the execution of low-speed go-arounds.

1.17.2.1.3 Type rating

The CRJ-100 and 700 are covered by a single rating. For a CRJ 100 pilot to operate a CRJ-700 at Brit Air, he must have performed two hundred flight hours on the CRJ-100, have followed a course on the differences between the two aeroplanes, undergone a simulator session, and performed a round-trip flight under an instructor's control.

1.17.2.1.4 CRM training

Training in Crew Resource Management is defined in document 022461 dated 28 December 1998, produced by a company called Dédale and registered with the civil aviation authority (DAC Ouest). The 2003 ECP program made reference to this document without detailing its contents. The program takes place over four

years, theoretical courses being delivered by Icare instructors using manuals supplied by Dédale. Practice sessions have an average duration of two hours and are performed every twelve months during the “OPS 1” training course. Certain aspects of CRM are also covered in practicals during simulator sessions, and during in-flight tests. Given the type of training, there is no specific examination; rather the instructor gives an assessment, entered in the pilot’s file.

Note:

- The content of CRM training was explained in the 2004 ECP program.
- There is no certified training course for CRM trainers.
- Icare instructors delivering the annual two-hour practical training had not received specific training in CRM pedagogy. This training is now provided by an outside supplier.

1.17.2.2 Cabin crew

1.17.2.2.1 Initial training

Initial training for cabin crew comprises two weeks of theoretical courses including cabin-simulator sessions. The simulator sessions do not include specific training of cabin crew members in management of emergency situations under marginal conditions, notably the presence of fire or smoke. Candidates then receive in-flight training before being qualified as flight attendants (“HST”).

Cabin crew also attend two additional training courses consisting of theoretical sessions (unruly passengers, lasting seven hours), and Quality.

Cabin crew must serve at least four years in the "HST" grade before moving up to Chief Purser and eventually Instructor.

1.17.2.2.2 Recurrent training

Cabin crew undergo an annual four-day recurrent training course and three hours training on the subject of unruly passengers. They are also flight-checked once a year by a cabin crew instructor.

1.17.3 Brest Guipavas ATC

1.17.3.1 General

1.17.3.1.1 Brest FIR

Brest Flight Information Region has various control organizations: En-Route Flight Advisory Centre West ("CNRNAO" in French), designated "Brest"; Atlantic Maritime Region ("RMA" in French) (designated "Landivisiau"); and Brest Guipavas Approach Control Centre (designated "Iroise"). Procedures between these respective organizations are defined in a General Letter of Agreement issued by Brest FIR on 20 April 2000, of which the following paragraphs are an extract.

1.17.3.1.1.1 En-Route Flight Advisory Centre West

Brest shall provide air traffic services in the controlled airspace of Brest FIR, under the call sign "BREST CONTROLE". Brest shall provide the flight information service in Brest FIR, under the call sign "BREST INFO". In the same airspace, Brest shall provide radar service under the call sign "BREST RADAR".

Brest shall employ its local primary radar image and a multi-radar image processed by the radar processing system (RPS). The said radar means allow provision of all or part of the radar functions, or coordination support.

1.17.3.1.1.2 Atlantic Maritime Region

Landivisiau shall provide air traffic services for general air traffic in specialized controlled airspace, under the call sign "LANDIVISIAU APPROCHE". In the controlled airspace under its remit, Landivisiau shall manage aeroplane departures and arrivals at Guipavas, Landivisiau and Morlaix.

Landivisiau shall provide radar monitoring, assistance and vectoring for general air traffic under the call sign "LANDIVISIAU RADAR". Landivisiau has a CENTAUR radar and receives remote RPS images from Brest.

Landivisiau shall inform Brest, Lanvéoc, Guipavas and Morlaix of its actual service opening and closing hours, by telephone, and confirm same by an AFTN message. Landivisiau shall switch on its automatic information-answering equipment ("RAI") when off duty.

1.17.3.1.1.3 Brest Guipavas Approach Control Centre

Iroise shall provide air traffic services for aircraft using the airspace […] described in Appendix 7, under the call sign "IROISE APPROCHE". When Landivisiau is closed, Iroise shall manage aircraft departures and arrivals at Guipavas, Quimper, Landivisiau, Lanvéoc and Morlaix.

Iroise shall provide radar monitoring functions in the said airspace, under the call sign "IROISE RADAR". Iroise shall have access to the radar images supplied by the Brest RPS and displayed via the IRMA system.

All arrivals at Guipavas shall be co-ordinated by telephone. Brest shall inform Iroise of the estimated time of arrival at the initial approach fix. Iroise shall issue a suitable clearance for an initial flight level.

1.17.3.1.2 Reference documents

Various documents are made available to the control-tower personnel at Brest Guipavas. They are grouped together in an Operations Manual and a Briefing Book containing standing orders.

The Operations Manual is a general document. According to the Brest air traffic control work teams interviewed by the investigators, this document is judged as inadequate because it is not updated regularly.

The Briefing Book is not organized and does not cover all of the points in the Operations Manual.

After the investigation into the collision of two aircraft at Paris Charles de Gaulle Airport on 25 May 2000, the BEA recommended that the DGAC put in place a precise definition and checking procedure for control-tower operations manuals. In fact, a precise reference document, structured and updated, reinforces homogeneity of working methods and terminology, and therefore safety. The DGAC has since defined an operations manual model with which ATC organizations should be in compliance by 1 January 2005. The DGAC also set up a procedure for checking operations manuals.

1.17.3.2 Night controller staffing

Two controllers operate the tower from 18 h 00 till 06 h 00 the next morning. They work as a pair from 18 h 00 till 21 h 00 and from 04 h 00 till 06 h 00. Between 21 h 00 and 04 h 00, when no regular flights are programmed, they work in turns, one controller being on duty, the other resting. The latter remains available for duty if required.

During the accident, per the above work arrangement, only one controller was on duty in the control tower.

1.17.3.3 Procedures and practices

1.17.3.3.1 Procedures and terminology

The approach-procedures and holding-procedures sections of the Air Traffic Regulations, and the air traffic terminology training manual, specify which procedures and expressions shall be employed.

In the event of a programmed hold, the controller must indicate the holding reference point, the flight level, and possibly the estimated time of arrival or the expected hold duration.

When issuing an approach clearance, the controller must indicate the authorized procedure, if the latter differs from the procedure in service transmitted to the aeroplane at the first contact or via the ATIS service. For an aeroplane cleared for a full-instruments approach procedure, the clearance is given before the IAF. The crew is “cleared for approach” and is then “cleared for landing”.

In the case of France Charter Flight 801, which preceded F-GRJS, the approach controller cleared the crew for an ILS 26 approach, and asked them to report "when established on localizer" [8]. When the crew reported back, they were cleared to continue the approach, and the controller asked them to report when passing the Outer Marker. The controller finally cleared the crew to land. The authorized procedure was correctly followed and certain additional reporting points were employed ("established on localizer" and "... Outer Marker").

In the case of Brit Air Flight 672 EC, the approach controller asked the crew to perform a holding pattern. The holding point was specified ("GU"), as well as the foreseeable hold duration ("one circuit"). There was no reminder given by the controller of the authorized procedure and the approach clearance employed non-standard terminology ("*Brit Air Echo Charlie the aeroplane in front has landed continue the approach report at Outer Marker*). The crew was then cleared to land.

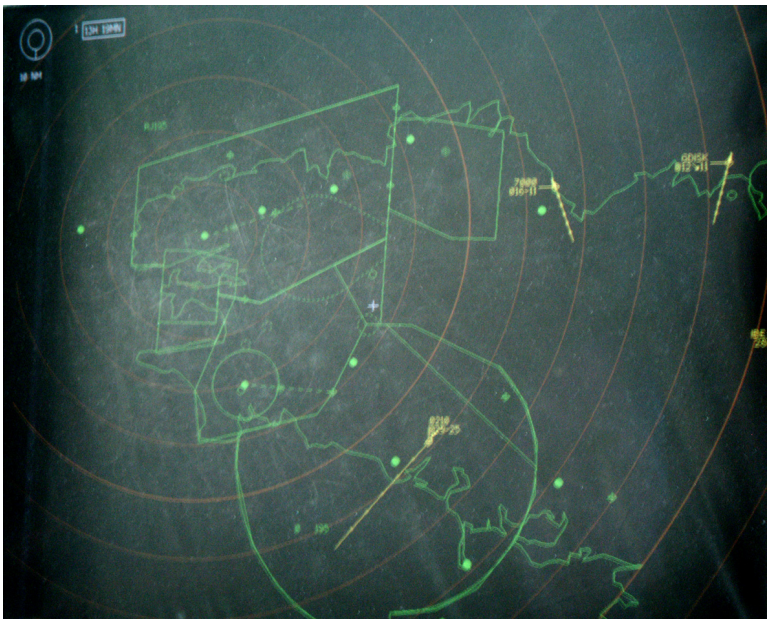
1.17.3.3.2 Utilization of the IRMA display system

The IRMA display system provides radar monitoring, assistance and vectoring services for qualified centres. RCA 3 defines the use of radar in Chapter X: "*Radar monitoring consists in using the radar to better determine the position of aircraft*" and "*radar assistance consists in using the radar to provide aeroplane with information concerning their position or deviations from their course*". The Brest Guipavas control authority is not authorized to provide a radar vectoring service. The AIP indicates "*Iroise Radar employs radar monitoring and radar assistance functions in the provision of control, flight information and warning services*".

Paragraph 4.3.1.2 of RCA 3 states that "*the pilot in charge of the aeroplane is responsible for preventing collisions with terrain, unless he is flying under radar vectoring*". The approach controller is therefore not under any obligation to continuously monitor the aeroplane's flight path on radar.

A technical guide to IRMA is available at Brest Guipavas. On the other hand there is no standard operating procedure. In practice, the controllers use the system to ascertain the positions and spacing of aircraft,. The controller can display different scales on the screen. The scale most often used at Brest Guipavas is the "ten nautical mile" scale, which enables visualization of the whole of Brittany.

[8] This is the standard message to indicate the end of radar vectoring (RCA3 § 10.7.3.3).



1.17.3.3.3 Low visibility procedures

Regulations in force

Chapter VI of the decree of 25 August 1997 relating to aerodrome certification conditions and operating procedures defines low visibility procedures (LVP) for "*the runway used for Category II or IIIS precision approaches*". It should particularly be noted that:

"Category II and III precision approaches shall only be authorised if low-visibility procedures are in force for the runway in question."
"These procedures shall ensure that sufficient separation is maintained between aircraft following each other on approach, such that the first has time to land normally and clear the runway and ILS areas before the following aeroplane reaches a point 2 NM from touchdown. The exact separation distance will depend on the configuration of the runway and its exit points, but generally, an appropriate distance between two aircraft following each other shall be considered as 10 nautical miles.

Landing clearances shall only be issued to an aircraft on approach when the ILS areas have been cleared; the aircraft must also be more than 2 NM from touchdown.

The implementing of LVP's will be announced on the ATIS for aerodromes employing this system, otherwise on first contact with the aeroplane on the appropriate control frequency.

Note:

- The chapter entitled "Runway used for Category I approaches" makes no mention of LVP's. If the RVR falls below 800 m, various measures must be taken (lighting system, alerting of emergency services...), but no mention is made of a possible increase in separations between aircraft on landing, as is the case in LVP's;

- The decree of 25 August 1997 does not specify whether it is possible to perform Category I approaches when the aerodrome is under LVP conditions. The decree was modified on 28 August 2003 and the chapter entitled “Runway used for Category II precision or III approaches” received additional text: "*When LVP procedures are in force, Category I precision approaches remain possible provided the Category-I minima are observed*".

Instructions in force at Brest

The duty controller stated that at the time of the accident, he had implemented low-visibility procedures. The “LVP procedures” standing order, dated 29 April 2003, sets the relevant conditions for Brest Guipavas. It is reproduced in Appendix 8. It should in particular be noted that:

It shall be mandatory to implement LVP procedures for the following meteorological conditions: lowest measured RVR below 800 metres, or cloud base ≤ 200 ft.

- *The use of LVP's shall be recorded on the ATIS.*
- *Lighting system operational.*
- *ILS locked.*
- *Inform the airport fire fighting service: runway inspection and clearing of critical ILS- areas.*
- *RVR's to be communicated to pilots.*
- *Observance of separation distances between aircraft: following an arrival, the second aeroplane shall only be cleared to begin its approach once the runway is clear.*
- *Pushback shall be authorised only if the aircraft can take off before the commencement of the CAT II or CAT III approach of the inbound aircraft.*

The latter sentence appears to show that, for those drafting the instruction, the implementation of LVP's implies that aircraft are performing CAT II or CAT III approaches. This instruction stems from the decree intended to protect these types of precision approaches. Since Brest ordinarily authorises these types of approaches, the instruction does not allow for the case where the aerodrome is restricted to Category I.

1.17.3.4 Controller training

1.17.3.4.1 Initial training at Brest Guipavas

Controller training for personnel staffing the Brest Guipavas tower takes place in two stages: controllers first receive their airport certificate, then their approach controller certificate. At each stage, they undergo theoretical training delivered by the regional instructor, and practical training delivered in the control tower by qualified Brest Guipavas controllers. Each phase is assessed in the form of an oral exam by the local board and in a practical examination in the control tower, again by qualified controllers.

An understanding of flight control techniques is passed on to controllers during their initial training at the National Civil Aviation School (ENAC); this aspect is not covered by recurrent training programs.

1.17.3.4.2 Recurrent training

Controller qualifications, including authorization to practice, are awarded on a three-year basis (renewable). The renewal procedure includes an English-language training course lasting at least two weeks, a test of knowledge of general ATC procedures and special procedures associated with the aerodrome. These tests are corrected and validated by a jury made up of controllers from the aerodrome. In addition, candidates for renewal must have had a minimum of three hundred controller hours in the previous year. Recurrent training is validated by a controller responsible for renewing authorizations.

1.18 Additional Information

1.18.1 Low Go-arounds

A Commercial and Business Aviation Advisory Circular was issued by Transport Canada on 13 May 1998 following the accident to a CRJ-100 at Fredericton (Canada) on 16 December 1997. This circular, whose aim is to inform pilots and aircraft operators of the potential dangers associated with a missed landing or low-speed go-around, does not only relate to the CRJ-100.

In the circular, a balked landing is defined as follows:

- *the aeroplane flaps and landing gear are in the landing configuration;*
- *the aeroplane is in descent;*
- *engine thrust is stabilized close to the "in-flight idle" regime;*
- *the speed is decreasing;*
- *the height of the aeroplane is 50 ft or less above the runway (50 ft is a representative value - a given aeroplane may make a balked landing above or below 50 ft, depending on the approved landing procedures for the type).*

The circular specifies that "*the decision to make a balked landing in an aircraft is a decision that prefigures a landing. If any doubt remains regarding the probability of a completely safe landing, a go-around or a missed landing must be initiated before entering into this type of landing. Attempting to initiate a go-around or a missed landing in a balked landing configuration is a high-risk manoeuvre and one that has not been tested. Should this measure be necessary, pilots must be aware that there is a possibility of contact with the ground* (that is to say, there is a risk of greater height-loss than with a standard go-around) *and that any attempt to start the climb before the engines have reached go-around thrust can lead to a stall".*

This circular was addressed to Canadian operators and foreign operators providing services in Canada. According to Transport Canada, the document was not circulated more widely, specifically not in France.

For its part, Bombardier has incorporated balked landings in an aeroplane into its training program. At that time, Brit Air pilot training was already provided exclusively by Icare and the subject was not covered in its training program.

A brief procedure called ["missed landing" is covered in the Brit Air operations manual. It appears similar to the subject presented by Bombardier as "balked landing", but no further explanations are provided.

1.18.2 Procedures in Place at Brit Air

Note: The following information is extracted from the Brit Air Operations Manual for the CRJ-100, and includes occasional commentary regarding the circumstances of the accident flight of June 22 2003. Paragraphs in italics are quotes.

1.18.2.1 Mode-changes and parameter displays

Any change of mode or display of parameters is the exclusive decision of the PF, and is announced by the PF and checked and confirmed by the PNF.

Note: Few clear announcements concerning changes of mode or parameter displays took place during flight AF 5672.

1.18.2.2 Procedures relating to approaches

1.18.2.2.1 Pre-descent briefing

The purpose of the pre-descent briefing is to anticipate the preparation of the approach, and allow the crew to define a common strategy for the latter. It includes, inter alia, the following items:

- *top-of-descent altitude and safety altitude,*
- *type of approach; active runway,*
- *displayed radio means,*
- *top-of-descent distance on extended runway centreline,*
- *altitude for passing OM,*
- *procedure minima,*
- *go-around procedure,*
- *summary of essential points concerning the approach (CAT I, II or III),*
- *special criteria (for example, NOTAM's).*

Note: The pre-descent briefing performed by the PF was as follows: "for a standard ILS … eleven one; three hundred and thirty-eight and five hundred and twenty displayed". Here he was stating the number of the approach chart ("11.1"), the frequency of the GU marker beacon ("338 MHz"), and the decision altitude ("520 ft").

1.18.2.2.2 Category-I ILS approach

The HDG mode must be used before the localizer interception phase.

Flight phase / Event	***PF***	***PNF***
Intersection heading and clearance	*Selects or controls the approach mode* *Announces "LOC white, GS white"*	*Calls out "check"*
LOC active then LOC capture	*Announces "LOC green"*	*Announces "LOC active"* *Calls out "check"*
At two points from glide slope	*Flaps 20 commands; selecting of VT*	*Announces "GS active" then flaps and VT announcements*
At one point from glide slope	*Landing gear commands*	*Landing gear announcements*
On the glide slope	*Flaps 30 ; selecting of VT – 10*	*Flaps and speed announcements*
Before OM	*Flaps 45 commands; selecting of Vapp* *Orders pre-landing check-list*	*Call outs concerning flaps and speed* *Reads the pre-landing check-list*

Flight phase / Event	***PF***	***PNF***
At OM	*Checks crossing altitude and Announces "OM XX ft, Cue"*	*Takes a cue and Announces "check"*
GPWS "500" announcement	*Announces "cleared"*	*Answers "standby for clearance"*
DA +100	*Seeks visual references*	*Announces "plus 100"*
DA and visual references acquired	*Announces: "contact"*	*Announces "decision"*
DA and visual references not acquired	*Announces "go-around"*	*Announces "decision"*

Errors of judgment or deviations from standard procedures must immediately be brought to the attention of the other pilot. Typical warning messages used during an approach are:

- *"LOC" when the observed deviation exceeds one point from LOC on a standard ILS,*
- *"GLIDE" when the observed deviation exceeds one point from GLIDE on a standard ILS,*
- *"VARIO" when the vertical speed exceeds 1,000 ft/min,*
- *"SPEED" when the airspeed error exceeds +10 / -5 kts in relation to the correct value.*

Note: The deviations noted during the approach of flight AF 5672 were not announced in a standard manner. The announcements relating to passing the OM, and "500 ft" and "DA +100 ft" were not made.

The operations manual states that the "*Brit Air stabilization height for all aeroplanes in IMC and VMC, is set at 1,000 ft AAL*, but there is some heterogeneity. For example, the LOC and GLIDE announcements, mentioned in the chapter relating to aeroplane control below one thousand feet AGL and requiring execution of a go-around, relate solely to excessive deviations (LOC or GLIDE information blinking amber on the PFD). However, these flashing warnings only appear below six hundred feet radio-altimeter height. Similarly, the stabilization height mentioned is, in places, five hundred feet (such as acquisition of visual references, or when the deviation applies to the descent rate, bank angle, or the pitch attitude).

After the accident, measures adopted by Brit Air included a new procedure relating to the stabilization height: when transiting one thousand feet AGL, the PNF says “one thousand feet stabilized” or “one thousand feet not stabilized” and the PF must answer either “continue” or “go-around”.

1.18.2.3 Go-around

The go-around must be started by pressing the "Go-around" button ("TOGA"). The PF must follow the commands on the FD bars manually, to obtain the go-around pitch attitude. The FD only gives an Attitude Indication (ten degrees). This pitch attitude does not guarantee reaching the climb speed. Consequently, it is necessary to go through SPEED mode (=speed-holding mode) immediately after the attitude hold.

Work-sharing between the PF and the PNF during go-around is shown in the following table:

Flight phase / Event	***PF***	***PNF***
Missed approach	*- “Go-around” command* *- Activates the GA pushbuttons, displays the go-around pitch attitude and initializes GA thrust.* *- Announces “GA GA green, display go-around thrust, flaps eight”*	*- Verifies the FMA and announces “check”* *- Checks that N1 is reached* *- Retracts the flaps to 8°.* *- Announces “go-around thrust displayed, flaps eight”*
Positive climb	*- Orders “gear up”*	*- Announces “VSI positive”* *- Sets L/G control to "UP"* *- Monitors attitude and speed; checks the flight path*
Established climb, V2GA +10 minimum	*- Orders “display speed mode”, display “heading mode”*	*- enters commands on FCP and Announces “speed mode, heading mode displayed”*

The operations manual also includes heterogeneity in go-around procedures. For example, the text above specifies that *the attitude display must immediately be followed by activation of the SPEED mode*, whereas in the table this mode must be activated *when the aeroplane is on an established climb at a speed of V2GA +10 minimum*; on a diagram found later in the operations manual the mode is activated during climb, at a speed of V2GA.

1.18.2.4 Procedures relating to GPWS alarms

At night or in IMC:

AURAL WARNING	**ACTION**			
	Automatic response	**Pitch Attitude**	**Thrust**	**Configuration**
PULL UP TERRAIN TERRAIN TOO LOW TERRAIN	*Disengage the autopilot.*	*3°/sec. rotation towards a target attitude of 20° until stick shaker limit, then maintain attitude at stick shaker limit.*	*Maximum thrust.*	*Maintain configuration except for flight spoilers (to be retracted).*
SINK RATE DON'T SINK TOO LOW GEAR TOO LOW FLAPS	*When the corresponding alarm sounds, take the corrective action. Note: The "TOO LOW FLAPS" warning may be deactivated by setting the "GPWS/FLAP OVRD" selector to "OVRD" for procedures approved with a flaps position other than 45°.*			
MINIMA	*When the MINIMA alarm is heard, confirm descent under minima and take corrective action.*			

The aeroplane captain must submit a written report for any GPWS alarm that leads to an emergency GPWS manoeuvre.

1.18.3 Regulatory environment regarding approaches

OPS 1, incorporated into French regulations by the decree of 12 May 1997, defines the regulatory aspects for approaches in the context of public transport.

Minima for preparation of IFR flights

The operator shall only select a destination aerodrome and/or an alternate aerodrome if meteorological observations or forecasts, or any combination of the two, indicate that, for the period commencing one hour before and ending one hour after the estimated time of arrival, the meteorological conditions will be equal to or greater than the minima applicable for preparation of the following flight:

flight preparation minima for a destination aerodrome:

- *(i) specified RVR/Visibility complies with regulation MIN 1.225 (aerodrome operational minima);*
- *(ii) and for standard approaches and visual flying manoeuvres, the ceiling is equal to or greater than the MDH;*

Conditions during approach and landing

Prior to commencing an approach with a view to a landing, the aeroplane captain shall ensure, based on the available information, that the meteorological conditions applying at the aerodrome, and the condition of the intended runway, do not prevent execution of an approach, landing or missed approach in safe conditions, based on the performance information contained in the operations manual.

Beginning and continuation of approach

The aeroplane captain or the pilot flying may begin an instrument approach independently of the announced RVR/Visibility, but he shall not continue the approach beyond the outer marker or an equivalent position if the transmitted RVR/visibility is less than the applicable minima.

If, after passing the outer marker or an equivalent position determined per the conditions of [the above paragraph], the transmitted RVR/visibility lies below the applicable minima, the aeroplane captain or the pilot flying may continue the approach down to the decision altitude/height (DA/H) or the minimum descent altitude/height (MDA/H).

The approach may be continued below the DA/H or the MDA/H down to a full landing, provided that the requisite visual references are acquired at the DA/H or the MDA/H, and maintained.

1.18.4 Testimony

1.18.4.1 Testimony of surviving crew members

1.18.4.1.1 Co-pilot

Sunday 22 June 2003 had started with the crew briefing in the operations office at around 16 h 30 local time, one hour before the estimated takeoff time. The rotation involved four stages: Brest - Nantes, Nantes - Strasbourg, Strasbourg - Nantes, and then Nantes - Brest. Upon arrival at Brest, the crew had learned that there would be an aeroplane change at Nantes. They performed the first leg on a CRJ-700. Since the aeroplane had had a technical problem, the takeoff took place about one hour late, towards 18 h 30 min. In Nantes, the first stopover, the aeroplane was replaced by the CRJ-100 registered F-GRJS.

All of the flights on the day went according to plan, with no problems reported other than those associated with the delay and the missed take-off slots.

On the last Nantes - Brest leg, the Co-pilot was then PNF, as planned since departure. Shortly after takeoff, noting that the aeroplane weather radar showed the presence of storms preventing him from following the course programmed in the FMS, the crew asked the Regional Traffic Control Centre for a more northerly course and a higher altitude, which was accepted.

During climb, the Co-pilot listened to the ATIS information at Brest. He remembered noting “200 ft ceiling, 2,000 metres visibility”. When he established radio contact with Brest Guipavas control, he noted the latest meteorological information “visibility 800 metres with fog”. At this juncture, the meteorological conditions allowed an approach to be performed.

When they received a call to plan for a hold at GU, the crew reduced the airspeed, and left 4,000 ft altitude to ensure arriving over the IAF (BODIL) at 3,000 ft. The controller then cleared the flight to descend to 2,000 feet.

Between BODIL and the GU beacon, the crew was informed that there was no longer a requirement to hold, and that the aeroplane could perform a direct approach if ready. The Co-pilot thinks that at this moment the automatic pilot was in "HDG" mode, engaged by the Captain for the holding pattern. In agreement with the Captain, he responded that they would perform the approach. The approach was undertaken without any use of the HGS, in compliance with the operator's procedures.

They were cleared to land once the aeroplane passed the GU marker beacon at 2,000 ft. The Co-pilot seemed to remember the Captain then changed to "APP" mode. Noting that the aeroplane was not following the glide path, the Captain switched to HDG and V/S modes in order to lock onto the glide path, but he did not maintain the aeroplane on the extended centreline. The Co-pilot pointed this out to him, and he seemed to remember the Captain replying, "I'm correcting”. He was starting to prepare for a go-around.

He believed he remembered that at the time he heard the "Glide slope" alert, he repeated the announcement, expecting a go-around, but nothing happened. He looked at the Captain. The latter was sitting in a normal position, staring at the instruments, both hands on the control column.

The Co-pilot then activated the TOGA selector himself, while looking at the Captain. The latter was staring at the instruments, not reacting to the actions being undertaken. The Co-pilot pulled back on the controls, which appeared to him to be blocked, and he pushed the throttles forward without being able to quantify the thrust displayed. He did not pay attention to the aeroplane speed at that moment.

He then saw the landing lights illuminating a field. He tried to land the aeroplane as well as possible. On first contact with the ground, he adopted the safety position with his arm in front of his face.

He felt three small jumps during the ground run. When the aeroplane stopped, he undid his harness and got out. He performed no actions on the instrument panel (fuel shut-off cock, extinguisher or other controls).

Once outside, someone told him, "Everybody is out". He lay down and someone put a compress on his head. He saw someone with a fire extinguisher vainly attempting to extinguish the fire in the cockpit. He was evacuated to hospital by the emergency services.

During working sessions with the investigators, the Co-pilot clarified several points. He explained that for a large part of the approach, he had left the piloting loop to manage the radio and read the check-lists. He found it difficult to re-enter the piloting loop. Afterwards, he tried to analyze the situation and realised that the APPR mode was not armed. Once this mode was armed, the white "LOC" readout on the FMA made him realize that the aeroplane was not aligned on the LOC. He then looked at the HSI and saw that the aeroplane was to the left of centreline. He was never aware of the real deviation. He thought the fact that the flight director was continuously centred satisfied him that the aeroplane was established on the correct flight path.

The GPWS “one hundred” announcement made him aware of the nearness of the ground, and motivated him to say “I've nothing in front”, to suggest that the Captain should go around.

He also explained that his throttle input, extremely fast, was made with the palm of the hand, without grabbing the throttles.

The Co-pilot stated that during one of the first flights that they had made together, the Captain had told him that his role as SFI should not interfere with his functions as co-pilot. During the rotation, he had been anxious to maintain a good relationship with the Captain: he had confidence in the latter's flying capabilities.

1.18.4.1.2 Flight Attendant

The Flight Attendant came on duty one hour before the planned first-takeoff time. The first three flights took place normally, without problems.

For the Flight Attendant, the Nantes – Brest leg was normal up until the accident. There was no cabin service, given the short duration of the flight.

A short time before the landing, the safety instructions were carried out and she transmitted the message "Cabin ready" to the Captain, who replied. She then took her seat and attached her safety harness.

At seven different times she heard alarms in the cockpit. To her, these alarms appeared unusual, and very loud. Then the cabin lighting, which had until then been dimmed, went off. Almost immediately, there was a loud scraping noise. Numerous sparks appeared along the cabin walls. The deceleration, comprising some severe jolts, lasted about twenty seconds. During the aeroplane's ground run, the right forward door was torn off.

When the aeroplane came to a stop, she undid her harness and opened the cockpit door. The cockpit was severely damaged, and lit up by an outside fire; the seats were lower than she was. The Captain had been ejected forward out of his seat, and it seemed to her that the co-pilot was in place, slumped forwards.

Believing that the pilots were dead, she closed the door again and asked the passengers to evacuate the aeroplane by the service door. Considering the situation, she thought that she could neither ask the passengers to help, nor use the public address system. She did not think to use the megaphone.

About ten passengers left the aeroplane. She saw a ball of fire cross the aeroplane towards her and since the heat and the fire were becoming unbearable, she also left the aeroplane. She stood at the foot of the service door and continued to help those passengers still aboard to get out. The fire was widespread and enveloping the entire fuselage as far as the over-wing emergency exits.

Since no-one else was coming out she went over to the passengers who had gathered on a small road nearby when she heard the Co-pilot, who was calling her. She returned to the aeroplane and helped him reach the group that had gathered about twenty meters from the aeroplane. By the light of the burning aeroplane she observed that he had a large wound on his head. Not having a first-aid kit and unable to retrieve the one in the burning aeroplane, she made him a compress with some pieces of clothing. She remembered the Co-pilot telling her, “I wanted to go around but he didn't want to”.

She then asked a female passenger to count the passengers. She was told, "Sixteen”. However, she could no longer remember the number of passengers onboard, and could not return to the aeroplane to check whether all the passengers were in fact out, considering that the entire aeroplane was by now shrouded in fire.

She saw someone firing an extinguisher onto the front of the aeroplane.

The passengers were very shocked. Some wanted to go and look for help. She found it difficult to persuade them that it was better to remain together, close to the aeroplane. Not having a mobile phone, she asked a passenger who did have one to call the emergency number. She described the situation but her message was not taken seriously. Shortly after, she called again, and again was not taken seriously. She did not know to whom she had been put through.

About ten minutes after the accident, a local inhabitant arrived. He told her the name of the accident site ("Kérintin"). She then asked a passenger to dial the airport number. She gave the aeroplane's location, and told them of the urgency of the situation.

Approximately fifteen minutes after the accident, a camper van arrived, followed by a car. The two drivers provided woollen blankets, a survival blanket, torches and some clothes.

Thereafter several passengers again wanted to go and look for help. It was becoming increasingly difficult to persuade them to stay where they were.

Around thirty minutes after the accident, two fire trucks arrived. They immediately fought the fire, at first taking the passengers for local inhabitants. About ten minutes later, other emergency vehicles and ambulances arrived, and the passengers, the Co-pilot and herself were evacuated.

1.18.4.2 Controller

The Controller came on duty with a colleague on the evening of the accident at 18 h 00. As per instructions, they worked as a pair until 21 h 00, assisted by a trainee controller. Because the meteorological conditions had deteriorated, they implemented LVP's. The use of LVP's was not normally possible considering the presence of items of plant equipment in critical areas, but their decision was based on the desire to offer an additional level of safety to aircraft bound for the aerodrome.

At 21 h 00, the trainee recorded the ATIS, forgetting to indicate the activation of LVP's. He told the Controller, who replied that she would do this when entering into first radio contact with aircraft. The Controller then remained on duty alone.

She received information from the Regional Traffic Control Centre that two aeroplane were bound for Brest, arriving one just behind the other. During first contacts with these aircraft, she forgot to specify that LVP's were in force. She cleared the first aeroplane, France Charter 801, for an ILS 26 approach and asked him to report when established on the LOC, and to maintain high speed as far as BODIL.

She then asked the Brit Air, number two, to plan for a holding pattern at GU. She considered that the separation between the two aeroplanes during the transfer was too short to have them land one behind the other, all the more so since LVP's were in force, therefore separation standards were greater. The crew replied that they were reducing airspeed so she asked them to reduce to “minimum in smooth", in case the separation became sufficient to allow them to avoid performing the holding pattern.

France Charter 801 called to indicate it was established on the LOC, the Controller allowed him to continue with his approach. Since fog had by then come down on the aerodrome, she thought she would not be able to maintain visual contact with the aeroplane once the latter was down. Additionally, since the only lit taxiway was taxiway Charlie, the aeroplane would have to perform a 180-degree turn and come back up the runway to take the taxiway, which therefore doubled the time required to clear the runway. Therefore, the Controller asked the Brit Air to perform the holding pattern, while specifying that fog had descended. She then asked them to descend to two thousand feet for their holding pattern, since she wanted to keep the three thousand feet altitude free for a possible go-around by France Charter 801.

The Controller saw France Charter 801 land and heard its thrust reversers. She saw that the aeroplane was going to be able to clear the runway at taxiway Charlie. She then looked at the position of the Brit Air on the IRMA screen and saw it on the localizer beam centreline, between BODIL and GU, thus before the holding pattern. She believed it to be established, that is to say, following the localizer beam centreline, and considered that the separation between the two aeroplanes was sufficient for the runway to be cleared before the Brit Air would be on final. She also considered that the crew had the mandatory thirty seconds of stabilized flight required for configuring the aeroplane. Furthermore, the visibility was sufficient to allow her to visually verify that the runway was clear. She

therefore told the Brit Air to continue the approach. Receiving no reply, she asked them if they were ready for the approach and, receiving an affirmative answer, she asked then to report when at the Outer Marker.

The Controller then took care of controlling France Charter 801 on the ground. She looked at the radar screen repeatedly but no longer saw the Brit Air. This did not surprise her, because it was an area where lost radar contact was common. Once the runway was clear, she cleared the Brit Air to land. She heard the read-back. She stopped looking at the IRMA screen because she was busy dealing with the first aeroplane on the ground. Later, not seeing the aeroplane land, she called it several times and, receiving no answer, asked the emergency crew to head for the runway threshold, where she thought the aeroplane was.

The Controller stated never having seen that the aeroplane was not aligned on the localizer beam centreline.

1.18.4.3 Summary of instructor testimonies

The investigators interviewed several instructors employed by ICARE who had participated in the training of the two pilots. The Captain was described as rigorous, professional, calm, courteous and relatively reserved. The Co-pilot was described as rigorous and professional, with a strong character. Both were said to have good flying skills.

The instructors were also questioned as to their perception of differences in handling between the CRJ-100 and 700. These interviews indicated that the CRJ-700 had a more nose-up attitude on final. During AP disengagement on final on the CRJ-100, the elevator trim control systematically required a nose-up input, which was not the case on the CRJ-700. Furthermore, the amplitude of the nose-up input on the control column needed to be greater on the CRJ-100 than on CRJ-700 to obtain an equivalent result.

2 - ANALYSIS

2.1 Accident Scenario

2.1.1 Takeoff, Climb and Cruise

The meteorological conditions contained in the flight dossier received at Nantes were as good as or better than the applicable flight-preparation minima: the crew could therefore undertake the flight.

It was not until they were in flight that the crew learned of the presence of fog at the destination. Until that time, the crew had not been aware of the deteriorating visibility conditions. It should be noted, however, that the measured visibilities transmitted to the crew in flight, including during the approach, were greater than the requisite minima, and therefore implied no mandatory obligation to divert. During the following thirteen minutes, the crew's attention was practically exclusively directed at avoiding the cumulonimbus.

About five minutes before starting the descent, the Co-pilot said: “the speeds are entered”, which indicates initial preparation for the approach. Cruise lasted eleven minutes.

2.1.2 Management of the Descent, Preparation of Holding and Approach

The incomplete arrival briefing, prior to carrying out the pre-descent checklist, may indicate the onset of routine (crew returning to base, fourth flight of the day).

At 21 h 44 min 21 s, faced with deteriorating visibility, the Controller, taking the decision that she had hitherto put off, asked the Brit Air to perform the holding pattern. At that moment of the flight, the two pilots shared a joint plan: they were preparing to perform, on autopilot, the holding pattern programmed into the FMS. During the next few minutes they configured the aeroplane for the holding pattern. The autopilot was still in NAV mode, on the FMS source.

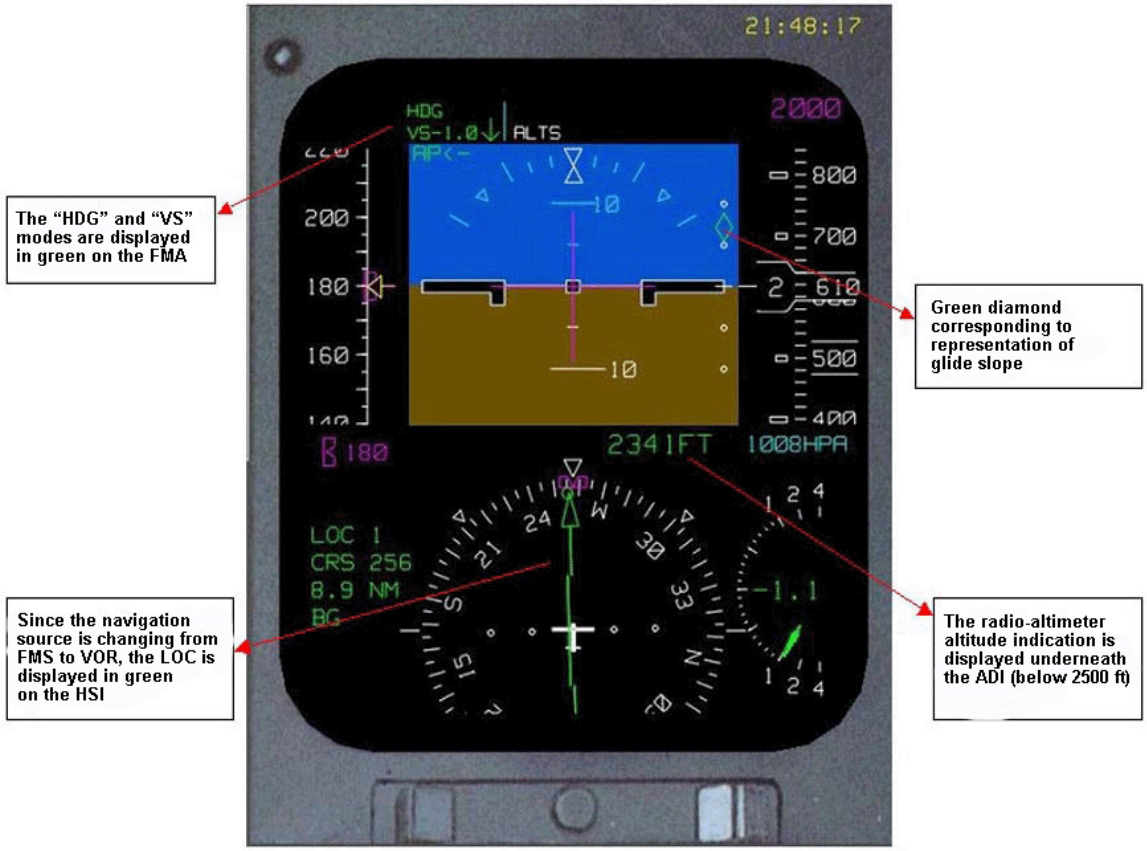
2.1.3 Approach Clearance – Non-arming of Approach Mode

At 21 h 48 m 01 s, while the aeroplane was at 9.5 NM DME and at the beginning of a descent from 3,000 ft towards 2,000 ft QNH, the Controller analyzed the position of the other aeroplane, which had just landed, and changed strategy. His message, and the terminology employed, “you continue the approach”, were well understood by the crew as a clearance to perform the approach. The crew changed their plan: the objective became to prepare the approach and configure the aeroplane with the intention of landing.

Immediately afterwards, the heading mode (HDG) was activated, without the corresponding verbal callout. The aeroplane, which was following a heading of 258°, was on the localizer centreline. The 109.9 MHz frequency (BG ILS for Runway 26) became active on the Captain's receiver, who changed the navigation source from "FMS" to "VOR".

At that moment, the PFD was displaying the following information:

Note: The PFD images in this part of the report were created at the BEA, using data from the flight recorders.



Not having received the readback from the crew, though it was transmitted, the Controller called them back. A short series of exchanges with the Co-pilot followed; during this time, the Captain was busy preparing the approach but his comments show that he was paying attention to the communications.

This very rapid sequence (twenty-five seconds) may be summarized in the following table:

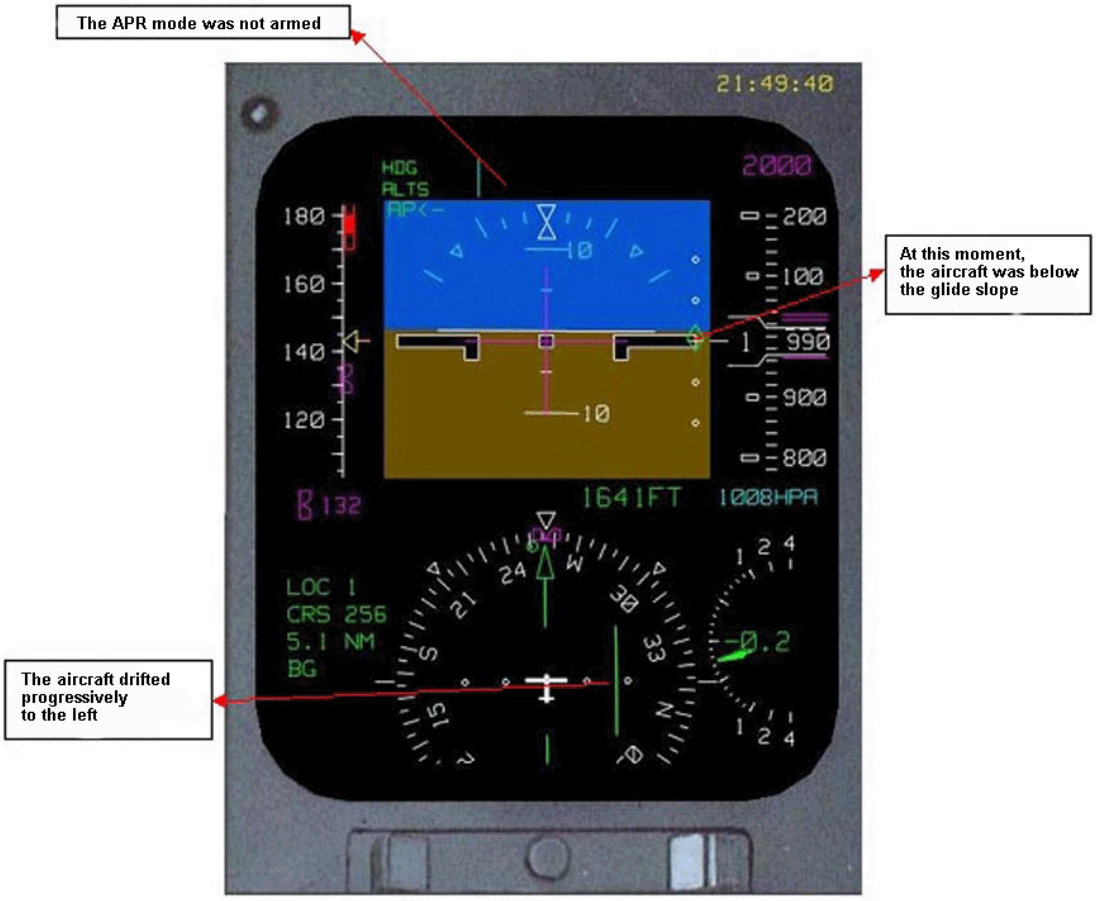
Time	Captain	ATC message	Co-pilot
48 min 01 s		Echo Charlie the one in front has landed you may continue the approach, report at Outer Marker	
48 min 04 s	HDG active		
48 min 07 s		*Note: message not received by the Controller*	"(OK) Will report at outer marker uh… and we continue on the centreline Echo Charlie"
48 min 09 s	ILS 1 active		
48 min 15 s	Source VOR mode		
48 min 18 s		Echo Charlie?	
48 min 19 s			Yes Echo Charlie
48 min 21 s		Are you ready for the approach?	
48 min 22 s			Affirmative
48 min 23 s		Report at Outer Marker	
48 min 24 s			We'll report at outer marker Echo Charlie
48 min 26 s	She didn't receive it		

Switching through "HDG" mode, changing the navigation source to "VOR", and activating the ILS frequency all correspond to actions prior to arming of the "APPR" mode. However, at the end of the said sequence, this mode had not been armed. In fact, had it been armed at that moment, the result would have been immediate capture of the localizer beam. In addition, there was no verbal announcement relating to pushing no the pushbutton or FMA mode display . Two explanations may be offered for non-arming of the mode: the Captain could have forgotten to do so at that moment, given the number of actions he had to perform in a short time, and, perhaps, the attention he was paying to the exchanges with the Controller; or perhaps he was waiting for the aeroplane to steady at 2,000 ft and, with his attention focused on managing the descent, he subsequently forgot. However, though it may seem improbable, it cannot be excluded that a rapid action on the pushbutton was not taken into account by the system. For his part, the Co-pilot did not check whether the "APPR" mode was armed. He also could have been troubled by repetition of the messages.

The aeroplane began to drift toward the left, in "HDG" mode, on account of the wind, which was progressively turning during the descent. At 21 h 48 min 51 s, the aeroplane exited the localizer capture beam.

2.1.4 Passing through the Glide Slope - Correction of Flight Path in Vertical Plane

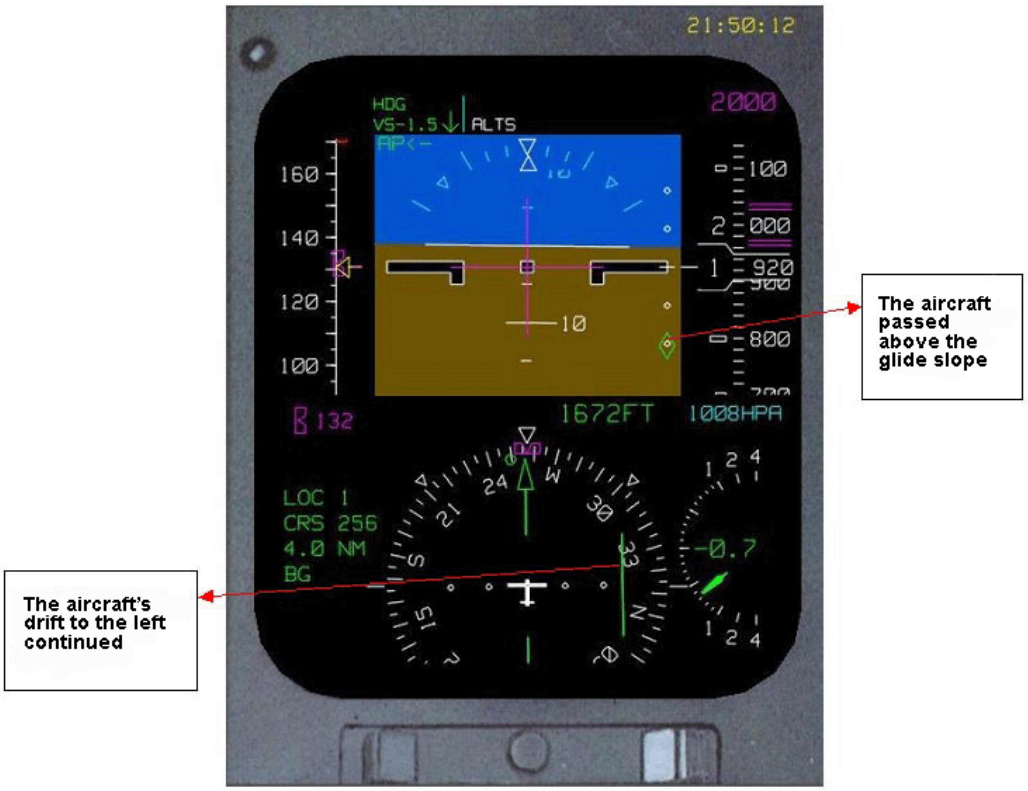
After the pre-landing checklist, the aeroplane arrived abeam the GU beacon; the Controller cleared the flight for landing on Runway 26 Left, and issued the weather information. The crew read back the clearance.
During these exchanges, the aeroplane passed down through the glide slope then passed back above. During this period, when the workload was very high, the crew did not detect the aeroplane's drift. For her part, the Controller indicated after the accident that she had looked repeatedly at the screen without seeing the aeroplane, probably because the latter was in an area where loss of radar contact was a known phenomenon.



Immediately after the end of these exchanges, sixteen seconds after the aeroplane passed through the glide slope, the Co-pilot said, "(…) we haven't got (*) approach (*)". These words are extremely difficult to hear and it has not been possible to reconstitute the whole sentence. The Co-pilot told the investigators that he had been out of the control loop while reading the checklist, configuring the aeroplane, and talking to Control. These words may mean that he was trying to analyze the situation, and the allusion to "approach" means that he was aware that the "APPR" mode was not armed. At that moment, the LOC display on the HSI attains right-hand stop. It will remain in this position until the ground impact.

Between 21 h 50 min 00 s and 21 h 50 min 12 s, the Captain, seeing that the aeroplane had passed above the glide slope, tried to have it descend in “VS” mode. The following modes were recorded successively: “ALT CAP”, “VS”, “ALT CAP” again, and finally “VS” at 21 h 50 min 12 s. This succession of commands can be explained by the fact that since the aeroplane was in level flight at 2,000 ft and the altitude selector was most probably set at 2,000 ft (the last authorised altitude), the first command was not accepted by the autopilot. It was necessary to change the target altitude in order to make the aeroplane descend: this is no doubt what the Captain did at the second attempt. The Co-pilot's exclamation at 21 h 50 min 09 sec., and the Captain’s remark “Oh didn’t it catch it?“ probably correspond to this difficulty, and, during the twelve second sequence, the crew’s attention is monopolised by the descent. The deviation with regard to the glide slope attained a maximum value of 2.1 points.

When the aeroplane passed the Outer Marker, according to the recorded parameters, it is likely that the “OM” symbol was not displayed on the PFD. The crew mad no announcement relative to passing the Outer Marker and did not report to ATC. (The frequency was, moreover, occupied by exchanges between ATC and the aeroplane on the ground).



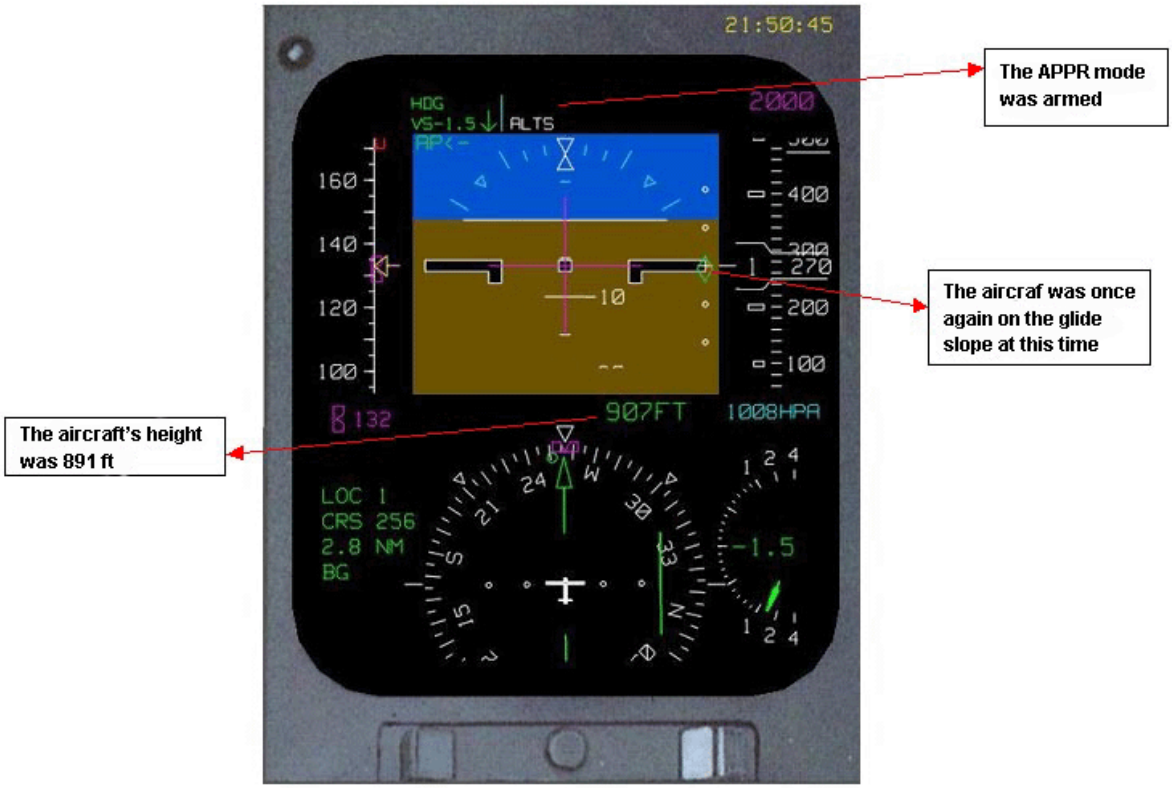
At 21 h 50 min 14 s, the Captain said “fifteen hundred, seventeen hundred, it’s OK”, then five seconds later “(Sixteen) hundred feet, it’s OK”. These figures probably represent the selected vertical-speed values of the “VS” mode. At that moment, the two pilots were focused on managing the aeroplane’s flight path in the vertical plane. The words “heading, VS” pronounced by the Captain show that he was aware they were in “HDG” mode. The deviation from the localizer had not yet been detected.

At 21 h 50 min 21 s, while the glide-slope deviation was decreasing (+1.75 points) and the localizer deviation was continuing to increase, the Co-pilot asked, “You’re getting it back. Do you want me to put the approach on for you?” The first part of the sentence shows that his attention remained focussed on recapturing the glide slope. The Captain declined the offer: still preoccupied with managing the descent, he was clearly not aware of the aeroplane’s position in the horizontal plane since he did not correct the heading.

At 21 h 50 min 32 s, one of pilots said “There it is, you're in", a remark that clearly relates to capturing the glide slope.

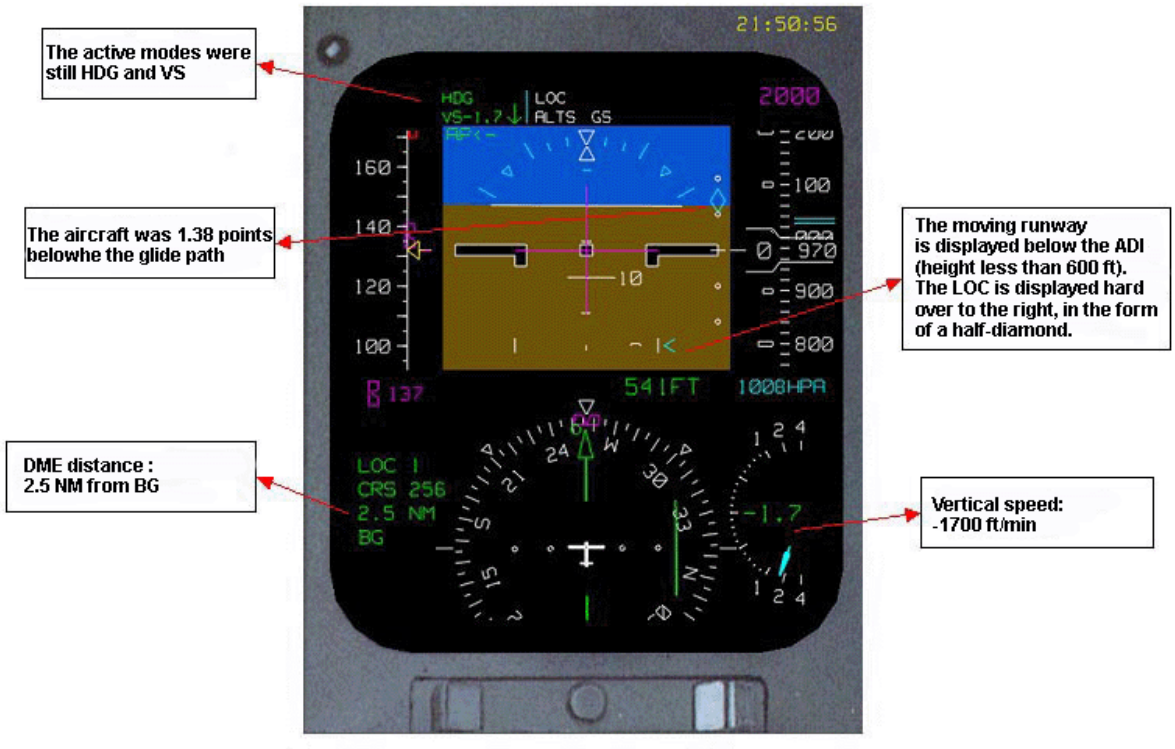
Throughout this phase of the approach, the flight director, which remained centred since the autopilot was in HDG-VS mode, could have reinforced the crew's perception that they were on the correct horizontal flight path.

At 21 h 50 min 45 s, the aeroplane captured the glide slope and the Captain announced, “The approach is selected LOC and GLIDE”. He had therefore just armed the "APPR" mode but, since the aeroplane was outside the localizer-beam capture envelope, no capture occurred. At that moment, while radar contact had been re-established, the Controller indicated that she had stopped looking at the screen because she was busy looking after the taxiing aeroplane and had already cleared the Brit Air to land. The aeroplane passed through and would remain under the glide slope until the impact with the ground.



2.1.5 Flight Path Correction in Horizontal Plane

Between 21 h 50 min 52 s and 56 s, the Co-pilot said “(*) come right” on two occasions, which clearly corresponds to a request to correct the flight path towards the right, therefore to an awareness as to the aeroplane's position in the horizontal plane. The Captain's answer seems to indicate acquiescence. In his testimony, the Co-pilot indicated that what made him realize that the aeroplane was not on the localizer centreline was seeing the white LOC display on the FMA. Seeing the LOC displayed hard over to the right on the HSI told him that the aeroplane was to the left of the planned flight path, without his realizing what the actual deviation was. The widened representation of the deviation in relation to the localizer centreline, which occurred at six hundred feet radio-altimeter height, at around 21 h 50 min 55 s, could also have contributed to his becoming aware of the aeroplane's position.



After the GPWS “Five hundred” announcement, numerous “Glide slope” and “Sink rate” announcements are heard. At the same time, the aeroplane began to turn to the right, which shows that the Captain was also aware of the aeroplane’s position in the horizontal plane.

At a height of three hundred and thirty feet, the autopilot was disengaged and immediately after, the Captain moved the elevator trim tab to the up position, which is a normal action when taking the aeroplane back under manual control. Since the elevator trim tab was actuated by the Captain, it is clear that it was also he who disengaged the autopilot. From there, the pitch, previously around -5°, increased to reach +0.6 at 21 h 51 min 11 s. This pitch change seems to have been a corrective action related to hearing the GPWS alarms. The engine thrust was lower than for a normal approach: 26% of N1 between 450 ft and 400 ft,

then 45% below 200 ft (the normal thrust on approach being around 65%). The corrective pitch input was therefore not accompanied by an adequate adjustment of thrust, the result being a significant loss of aeroplane energy: given the low engine speed and the increasing pitch, the airspeed decreased (130 kts at 400 ft, 120 kts at 100 ft, for a Vref of 132 kts). In addition, the wind rate nearer the ground (ten knots between 250 feet and the ground) also contributed to reducing the aeroplane's speed. Since the deviation below the glide slope continued to increase, it seems that the crew's attention was now focused on managing the lateral flight path, to the detriment of managing the vertical plane and the aeroplane's energy.

Between 21 h 51 min 11 s and 21 h 51 min 14 s, the Co-pilot said on two occasions "Come right". The captain seems to acquiesce once more. During his interviews with the investigators, the Co-pilot explained these comments as an offer to take over control. This, however, seems unlikely, given the terminology employed and the low level of stress in these announcements. It is more likely that this announcement related to the flight path. The Co-pilot may have a distorted vision of the last seconds of the flight because of the difficulty, in general, of remembering precisely the chronology of a succession of actions, and on account of the physical and psychological trauma he experienced.

2.1.6 Go-around

The Captain's announcement "Go around" at 21 h 51 min 16 sec occurred when the aeroplane arrived at the decision altitude, just after the GPWS "One hundred" announcement and the Co-pilot stating "I've nothing in front".

One second later, the engine parameters began to increase: there was therefore an immediate throttle input following the announcement. The first significant upward elevator deflection occurred three seconds after the beginning of the thrust increase. Given the nose-down pitching moment produced by the thrust increase, and loss of elevator efficiency due to low airspeed, the amplitude of the nose-up action was not sufficient to bring the aeroplane into an ascending flight path. The aeroplane pitch decreased from 0° to - 5°. That was where the first noise of impact was heard, at 21 h 51 min 22 s. The flaps and landing gear remained in the same configuration.

It is difficult to know what happened precisely in the cockpit during this sequence. The Co-pilot stated that as he had the impression that the Captain was passive, he had pushed on the TOGA button, moved the throttles and tried to modify the aeroplane's pitch by pulling back on the control column. The Co-pilot very probably had some input on the controls, but certainly later than he remembered. He stated that he made a rapid throttle input after activating the TOGA mode. However, this mode had been activated about four seconds after the start of the thrust increase. It is therefore likely that the throttle input was made by the Captain, partially or completely, and that the Co-pilot, when he intervened, may have completed the movement or indeed could have had the impression of pushing levers that were already in the full thrust position.

The Co-pilot indicated that he was not aware of the low speed of the aeroplane. He wanted to pull back on the controls, conscious of the nearness of the ground. The low amplitude of the elevator deflection, and the blocking sensation he felt on the control column, which he felt and attributed to the Captain, may have several explanations. Most likely is that pilots' attention was not focused on the same parameters: the Captain could have been monitoring the speed (which had dropped to 115 kt) and delayed his pitch up input, unaware of the aeroplane's height, in order to avoid a stall. The fact that he had started the go-around at the decision altitude shows that his attention was probably more centred on the altitude that on the height of the aeroplane. It is probable that he had set himself the decision altitude as a limit, considering that this altitude, which normally positions the aeroplane above two hundred feet AGL, provided an adequate safety margin, all the more so since a standard go-around on the CRJ-100 led to only a slight loss of altitude. However, the aeroplane, deviated from the centreline, was actually at a height of ninety-three feet. The fact that he had done his last go-around practice on the CRJ-700, which is more reactive in pitch-up mode than the CRJ-100, could have reinforced the Captain's belief in this respect.

2.1.7 Aeroplane's Ground Run

The first noise of impact probably corresponded to the main L/G hitting the wooded embankment. In fact, the marks left in the field were very superficial and do not explain the level of noise heard. Since the embankment lay at 45° to the flight path, the aeroplane was unbalanced; the left wing struck the ground and was cut off at one-third of its span. The fire broke out at that moment, as shown by the marks on the ground, which explains the sparks seen from inside the aeroplane.

The nose landing gear struck the wall and collapsed, then the aeroplane slipped into a ditch and hit the trees, which tore off the entire right wing, the left wing root, and the left and right landing gears. It was probably this shock that caused the flight recorders to cut out. The aeroplane then struck some poles, these later impacts seemingly causing the heavy damage to the cockpit and the pilots' injuries. Finally, the aeroplane continued onto the asphalt road, where it stopped.

The position of the MFCU's shows that the throttles had been moved to idle. In addition, the fuel cutoff switches and the pushbutton commanding the right extinguisher had been actuated. It is unlikely that these actions were the result of the impacts suffered by the aeroplane, considering the fact that the guard over one of the two fuel cutoff switches was recovered in place and in the down position. These actions appear to have been deliberate. Since the various teams at the site of the accident stated that they had not touched this part of the cockpit, it is very likely that these actions were performed by the crew during the aeroplane's ground run, between the end of the recording and the impacts with the poles, which would have prevented any intervention on the fuel cutoff switches and the extinguishers, and which cut the linkage between the throttles and the MFCU's.

The Co-pilot indicated that he had adopted a protective posture during the aeroplane's ground run, with both arms in front of his face, and he does not remember having performed the actions in question. It was therefore probably the Captain who pulled back the throttles then pushed the various pushbuttons as the aeroplane ran along the ground.

2.2 Decisions Relating to the Approach

2.2.1 Context of the Decisions

The decisions relative to the approach must be considered in the light of several factors. Firstly, the crew, being based in Brest, knew the aerodrome and its procedures very well, and they could have judged that a holding pattern was not necessary to prepare the aeroplane. Next, the makeup of the crew, a Captain experienced on the CRJ-100 and an SFI as Co-pilot, with considerable aeronautical experience, could have led to a kind of over-confidence, all the more so since the two men were used to flying together. Further, the crew could have been a little tense due to the aeroplane's lateness and the need to avoid the cumulonimbus. They could also have been tired, even if they were not aware of it: it was late at night, it was the fourth and last flight of the rotation and the Captain had got up very early the previous day to do a rotation. A holding pattern or a go-around might make it impossible to land at Brest, since the weather conditions were deteriorating.

2.2.2 Decision to Begin the Approach

While the crew was expecting to perform a holding pattern associated, in the Controller's messages, with the visibility conditions, the HDG mode had been selected immediately after read-back of the clearance "continue the approach", which shows that the decision was taken very rapidly. There was no verbal communication between the pilots, but it is possible that they confirmed their agreement by some gesture.

The fact that the aeroplane in front of them landed showed that a landing was possible, and this could also have acted as an encouragement to undertake the approach.

2.2.3 Decision to Continue the Approach after Passing through the Glide Slope

After passing through the glide slope, the pilots did not decide to abort the approach and they put the aeroplane into descent configuration. It is clear that they thought they could recapture the glide slope with an adequate safety margin, considering the aeroplane's altitude at that time. However, this non-standard manoeuvre increased their workload and made it harder to set up a stabilised approach.

2.2.4 Decision to Continue the Approach under 1,000 feet AGL

The possibility of a go-around had not been mentioned before the decision altitude; the Captain did not make a go-around decision, and the Co-pilot did not suggest one.

Initially, between one thousand feet (the stabilization height) and six hundred feet AGL, the crew's focused attention on locating the glide slope probably added to the aforementioned factors in deciding not to abort the approach. The crew was, however, aware during this phase that the aeroplane was not established on the glide slope, and that the vertical speed was not that of a stabilized approach. It is possible that they considered they still had the time to recapture the glide slope and stabilise the approach, taking into account the aeroplane's height.

Between six hundred feet AGL and the decision altitude, that is, for eighteen seconds, the pilots' focused attention on managing the flight path in the horizontal plane, the volume of unusual information being transmitted to them and the search for visual references could have hampered their ability to understand and their judgement, which may have led them to ignore the GPWS alarms. That was when the Captain could have considered the decision altitude as the ultimate barrier. The non-standard announcements by the Co-pilot relating to the flight path, and the Captain's omission, at five hundred feet, of the airline's standard "cleared" announcement did not help the crew to break away from focusing on the lateral deviation.

2.3 Work Environment

2.3.1 Teamwork

The two pilots were rigorous and had good flying skills, as seen from their assessment records and various instructor testimonies. However, their teamwork appeared dysfunctional during the flight and, more particularly, during the descent and approach phases.

During the flight, they communicated very little. The Captain's intended actions were not explicitly announced, and the Co-pilot did not ask for explanations. The same applied to standard procedures and announcements, which allow each pilot to know that what the other is doing.

In the absence of such co-ordination and communication, during the approach the pilots remained first separated in their respective work, then apparently focused on a given task without having any clearly defined common plan of action.

The factors stated in paragraph 2.2.1 (tiredness, stress and routine) may partially explain this lack of communication and co-ordination. Two additional explanations may be offered in trying to understand certain dysfunctional elements:

a) The pilots' training provided them with safety limits that were not effective. This shows the limits of the various line checks and base checks: the latter cannot

prevent a certain amount of drift in relation to the working methods that are taught. These deviations may appear insignificant on an everyday basis but they decrease the effectiveness of teamwork.

b) The Co-pilot's SFI function, which conferred him a particular status, may be one of the explanatory factors in understanding the low level of communication in the cockpit. The implications on crew teamwork of appointing an instructor or executive as a Co-pilot are not much mentioned during CRM training.

2.3.2 Operator's Procedures

Stabilization height

The stabilization height defined by Brit Air is one thousand feet AGL. At the time of the accident, no callout was required concerning passing through this height. Such a callout, notably if made by the PNF, would have allowed the crew to formalize a decision as to the continuation of the approach. The five hundred feet callout used by the operator could, in addition, appear to be an encouragement to take certain liberties with regard to the value of one thousand feet.

The low proportion of non-stabilized approaches resulting in a report (cf. § 1.17.1.2) would tend to demonstrate the low level of collective awareness regarding the importance, for safety, of stabilization.

A callout at the stabilization height has since been introduced by the operator. It is the responsibility of the PNF.

Management of GPWS alarms

The numerous "Glide slope" and "Sink rate" GPWS alarms after passing through the one-thousand feet level during the descent indicated that the approach was not stabilized, and they therefore implied the need to abort it. It should be noted, however, that the documentation does not make any connection between the general instructions relative to these alarms, which are to correct the flight path, and those relative to non-stabilization, which are to go around.

Furthermore, the GPWS announcements generated by the flight simulator are not identical to those generated in the aircraft. Differences in these warnings may, in flight, induce different behaviour than in training. In particular, in the case of this accident, it was noted that the simulator generated a "Minimums" announcement on passing through the decision altitude, whereas such an announcement is issued only if the crew selected a decision height. This point does not appear, however, as contributory to the accident of June 22, 2003, the Captain having started the go-around at the decision altitude.

2.3.3 Awareness of Low-speed Characteristics of the CRJ-100

Research on flight simulator performed at Icare appears to show that the impact with the ground was avoidable, even when commencing the go-around at 90 ft AGL. However, it should be borne in mind both that the pilots participating in these sessions were already aware of the event, and that the wind rate was not simulated.

Simulations performed by Bombardier indicate that impact with the ground was avoidable, albeit by the use of an atypical technique (see para. 1.16.5.3), which would have brought the aircraft practically to the stick-shaker threshold. The crew's room for manoeuvre was therefore particularly limited.

Since the environment of the go-around did not correspond strictly to that of a balked landing, it is not certain that this technique, had it been taught by Icare, would have prevented the accident. It is, however, likely that it would have contributed to it by increasing awareness to the low-speed characteristics of the CRJ-100. Such awareness could have allowed the crew to better understand the situation during the go-around.

In addition, there are differences between the go-around handling of the CRJ-100 and that of the 700, notably as regards longitudinal control. These points are not specifically covered during the course concerning the differences between the CRJ-100 and the CRJ-700, though pilots are called upon to fly on the two models regardless.

2.3.4 Flight Safety and Analysis

The airline's multibase structure, and the location of the Flight Safety and Analysis Dept ("SASV") complicate spontaneous circulation of information between pilots and the SASV. Additionally, due to the dispersed structure, crews are mostly made up of pilots based at a given site, who therefore fly together into bases with only a small number of pilots. This may lead to a phenomenon of habituation or excess confidence. The need for pilot-awareness regarding the benefits of feedback is therefore all the more important.

2.4 Display of LOC and GLIDE information

The aircraft's drift was not detected by the crew for about two minutes. The method of display employed for LOC and GLIDE information on the PFD is not limited to the CRJ-100 and 700 alone, and it meets the requirements of the certification regulations. However, separating the two items, even within a single screen, widens the visual scan that the pilots must perform when making an approach, and tends to make them focus on one of them. It is possible that the crew would have detected the aircraft's drift earlier if both sets of information had been presented in an interconnected manner.

2.5 Interface between Aircrew and ATC

2.5.1 Terminology employed

Although it did not result in any ambiguity between the Controller and the aircrews regarding understanding of their respective intentions, the terminology used was not the same for the two aircraft arriving. In addition, the approach clearance was given to the Brit Air without cancelling the holding pattern, and the clearance was not made with the standard expression “cleared for approach”, an expression that implies that the decision depends on the crew. It is likely that in this case, the crew would nevertheless have taken the decision to begin the approach, but the expressed used may have influenced them.

The Controller asked France Charter 801 to report when established on the localizer. The Controller did not ask the same of F-GRJS because he believed the aircraft was already established on the localizer. This announcement, used for radar vectoring, is not included in the regulations apart from for that purpose. However, if it had also been used with F-GRJS, it could have made the crew aware of the failure to capture the localizer.

2.5.2 Approach management strategy

Delaying the decision relating to the holding pattern, then the Controller's change of strategy after the landing of France Charter 801, were motivated by the same desire, namely to allow the aeroplane to land without unnecessary delay, especially as it was late in the day and the flight was already behind schedule. The Controller therefore tried to avoid having the crew wait at GU, while maintaining safety standards, which she considered adequate. Another factor clearly contributed to the Controller’s decision: seeing the aircraft on the BODIL-GU axis, she believed it to be established on the localizer. So, in the Controller's view, the aircraft was following this axis, from which no further departure was possible unless commanded voluntarily. Allowing the flight to continue on this axis therefore could appear to the Controller as the least constraining option from the flight-control viewpoint. All the more so since the holding pattern, the result of the separation minima imposed by the LVP instructions, the preceding aircraft not yet having cleared the runway, was justified by the protection of Category II or III precision approaches, which was not the case for the flight in question. That was why the Controller told the crew to “continue” an approach for which she believed their aircraft was correctly lined up, preferring to change strategy rather than to modify the flight path.

The crew immediately accepted the Controller's clearance, which did not give the controller time to realize the potential difficulties of such an approach. She therefore concentrated on managing the aircraft that was taxiing. The change of strategy, intended to facilitate the crew’s workload, paradoxically contributed to increasing its workload.

Note: The scale employed, and the presence of a zone of usual loss of radar contact, does not allow effective radar surveillance on final approach. Additionally, the absence of procedures associated with the use of the system prevents effective implementation of the latter.

2.6 Ground Proximity Warning System (GPWS) and MSAW

The simulation performed with the Honeywell EGPWS shows that a “Too Low Terrain” alarm would have been generated fifteen seconds before impact. Since aircrews are trained to take evasive action on hearing this alarm, an EGPWS would presumably have resulted in an earlier decision to start the go-around, that is, at a height of about two hundred and thirty feet.

The MSAW simulation showed that with the standard parameter settings employed, the Controller would have been alerted sixteen to twenty-four seconds before impact. Considering the time to transmit this alarm (cf. § 1.16.7.2), it would most probably not have allowed the crew to perform the go-around any sooner.

2.7 Evacuation

During the evacuation, some passengers headed toward the rear of the cabin, whereas the pre-takeoff safety demonstrations and the safety instructions clearly indicate that the CRJ-100 is not fitted with rear exits. The fact that one passenger opened an overwing exit, without previously checking that this could be done without danger, resulted in the fire violently penetrating the centre of the cabin, thereby immediately worsening the evacuation conditions. Only the small number of passengers, in particular aft of this exit, meant that no passengers were trapped by the fire. These errors may be explained by situation-specific factors, but also by the fact that few passengers follow the safety demonstrations attentively or read the safety instructions.

The Cabin Attendant managed the evacuation of the passengers, but she failed to remember their exact number and was therefore not able to ensure that all had actually disembarked from the aircraft. In addition, she did not think to use the megaphone or to take the first-aid kit when leaving the aircraft. These omissions did not have any consequences during this accident, but they could have had in other circumstances. The Cabin Attendant attributed them to the stress of the accident and the extreme emergency of the situation. It should be noted that the training of cabin personnel at Brit Air, although being essentially aimed at preparing crew members to face this type of situation, does not include near-real situations, which might have allowed the Cabin Attendant to better optimise her resource-management.

3 - CONCLUSIONS

3.1 Findings

- The crew and the controller possessed the requisite licenses and qualifications, which were valid.

- The aircraft had a valid Certificate of Airworthiness.

- The crew was undertaking a Nantes-Brest flight, the last stage of a rotation comprising Brest-Nantes-Strasbourg-Nantes-Brest legs.

- The crew was based in Brest and knew the procedures relating to the aerodrome.

- The aircraft took off from Nantes at 21 h 16 min with twenty-one passengers. It was about fifty minutes late, the delay having being carried over from the first leg.

- The Captain was pilot flying.

- Meteorological conditions at Brest worsened shortly before the takeoff from Nantes. The crew learned in flight of the deteriorating visibility at their destination.

- A NOTAM (Notice to Airmen) was in force, indicating that Category II and III approaches were unavailable at Brest Guipavas from June 2 to July 31, 2003; the crew were aware of this.

- The measured visibilities obtained before takeoff, during the flight, and during the approach were all greater than the requisite minima for a Category I approach.

- The aerodrome radio installations were in operational condition.

- The pre-descent briefing was not complete.

- The pilots communicated little during the approach and some announcements were omitted.

- The aircraft was “number two” on arrival.

- The approach Controller asked the crew to descend to four thousand then to three thousand feet and perform a holding pattern. She afterwards authorized descent to two thousand feet.

- The crew flew the approach on the PFD, without using the head-up system, in accordance with the operator’s procedures.

- After the preceding aircraft had landed the Controller, seeing F-GRJS on the localizer centreline on the radar, and believing it to be stabilized, asked the crew to continue the approach before they had started the holding pattern.

- The crew began the approach after this clearance, which they read back.

- The readback was not received by the Controller.

- The automatic flight control system APPR mode was never active. The beginning of the approach was performed in HDG and VS modes.

- The wind, which veered progressively northwest then north during the descent, caused the aircraft to drift leftwards. This drift was not detected by the crew.

- The aircraft exited the localizer capture beam.

- The aircraft passed above the glide slope and the pilot selected the VS mode to recapture the slope. The crew's attention was focussed on managing the flight path in the vertical plane. During this time, the aircraft continued its leftward movement away from the localizer centreline.

- The aircraft captured the glide slope from above and the crew's attention then focussed on the horizontal flight path. The aircraft passed through the glide slope and remained below the latter until the impact with the ground.

- The captain initiated a right turn and disengaged the autopilot.

- Numerous "Glide slope" and "Sink rate" alarms were transmitted without any significant reaction from the crew.

- The Captain started the go-around at the decision altitude. The aircraft, off to the left of the runway centreline, was at about one hundred feet AGL. The speed was low (between 115 and 120 knots).

- The first meaningful pitch-up action on the elevators was recorded four seconds after the thrust command.

- The aircraft continued to descend, impacted the ground without violence, ran along the ground, and then impacted several obstacles that heavily damaged the cockpit. The aircraft came to a halt after about one hundred and fifty metres.

- The emergency beacon did not work.

- Fire broke out during the aircraft's ground run; it remained localized outside of the cabin.

- The Cabin Attendant ordered the passengers to evacuate before the fire destroyed the cabin.

- During the evacuation, one passenger opened an over-wing exit; the fire then penetrated into the cabin.

- Inspection of the various components of the pitch control system did not reveal any anomalies.

- The emergency services had problems in locating the wreckage. They arrived twenty-seven minutes after the accident.

3.2 Probable Causes

The causes of the accident are as follows:

- neglecting to select the APPR mode at the start of the approach, which led to non-capture of the localizer then of the glide slope;

- partial detection of flight path deviations, due to the crew's focusing on vertical navigation then on horizontal navigation;

- continuing a non-stabilised approach down to the decision altitude.

Lack of communication and co-ordination in the cockpit, and a change of strategy on the part of the Controller in managing the flight were contributing factors.

4 - SAFETY RECOMMENDATIONS

4.1 Procedures in Force

At the time of the accident, Brit Air procedures did not call for an announcement when passing through the stabilization height. Such an announcement leads crews to establish a common strategy regarding continuation or missing the approach. Additionally, when issued by the PNF, it may encourage the latter to propose a go-around. The investigation also showed that the Brit Air Operations Manual made no connection between instructions on GPWS alarms and those relating to the stabilization height.

Consequently, the BEA recommends that:

- **the DGAC study the possibility of generalizing a procedure relating to passing through stabilization height, consistent with procedures relating to GPWS alarms.**

The Brit Air Operations Manual is somewhat inconsistent, in particular with regard to the stabilization height and go-around actions.

Consequently, the BEA recommends that:

- **Brit Air ensure that the content of its Operations Manual is consistent.**

4.2 Flight Crew Training

The investigation showed an absence of awareness by Brit Air pilots regarding the low-speed characteristics of the CRJ-100. A similar observation had already been made in Canada following a December 1997 accident. Bombardier has put in place a balked-landing training program, but the latter constitutes only a partial answer to this awareness requirement.

Consequently, the BEA recommends that:

- **the DGAC introduce awareness-training on the low-speed operating characteristics of the CRJ-100, and other aircraft presenting comparable characteristics during go-around, into its training programs;**

- **the DGAC inform foreign regulatory bodies of the above recommendation.**

The investigation showed that training for CRM trainers was not subject to specific approval by the DGAC, and that end-of-training skills were not checked.

Consequently, the BEA recommends that:

- **the DGAC, in association with its foreign counterparts, put in place a training-approval regime concerning training of CRM trainers.**

The SFI functions of the Co-pilot and a small number of other pilots based at Brest could have contributed to the inadequate communication and co-ordination between the crew.

Consequently, the BEA recommends that:

- **the DGAC ensure the incorporation of such factors in CRM training.**

4.3 Display of LOC and GLIDE Information

The option selected by Bombardier and Rockwell Collins for the display of localizer and glide information on the CRJ-100 PFD was to present the two items on the same screen but on two separate instruments, as permitted by the regulations. Utilization of an instrument such as the HGS, combining the two items, could have allowed the crew to detect non-capture of the localizer sooner.

Consequently, the BEA recommends that:

- **the EASA study the possibility of imposing the combining of localizer and glide information on instruments used for the approach phase.**

4.4 Interface between Crew and Air Traffic Control

The investigation highlighted the fact that the Controller, motivated by the desire to assist the crew, had changed strategy and cleared for approach belatedly. This could have contributed to precipitation in the cockpit during the preparation of the aircraft and the beginning of the approach.

It is therefore considered desirable for a multidisciplinary think-tank to evaluate the operational consequences on pilots of proposals from ground control and that the results of this study are made known to controllers. The BEA recently recommended "***the DGAC introduce the notions of ground/crew resource management into the training and practice routines of controllers and pilots. Feedback data could be used effectively to this end".*** This recommendation would appear to address the above issue.

An announcement of the type "report when established on the localizer" could have helped the crew to realize they had not captured the localizer. Similarly, procedures associated with use of the radar could have helped the Controller to realize that the final phase of the approach was not taking place normally.

Consequently, the BEA recommends that:

- **the DGAC study the possibility of extending to precision approaches, not preceded by radar guidance, the instruction to report back when the aircraft is established on its final approach flight path;**

- **the DGAC take measures to clarify utilisation of radar, and limitations of same, in particular for the surveillance function.**

4.5 Evacuation

Due to the stress associated with the accident, the Cabin Attendant did not think to use the megaphone during the evacuation, and forgot to take the first-aid kit when leaving the aircraft. She could not remember the number of passengers aboard, and could not be certain that all had actually disembarked from the aircraft.

Consequently, the BEA recommends that:

- **the DGAC study the introduction into training and practice sessions for cabin crew of near-real situational simulations.**

Moreover, carrying a megaphone aboard the CRJ-100 is not mandatory.

Consequently, the BEA recommends that:

- **the DGAC impose carrying a megaphone when the presence of a cabin attendant is required by regulations.**

During the evacuation, one passenger opened an over-wing exit. Fire then penetrated the cabin. Opening an emergency exit without first verifying for possible outside hazards may in certain cases prove detrimental to safe evacuation.

Consequently, the BEA recommends that:

- **the DGAC study the possibility of specifying the checks to perform prior to opening of emergency exits, for example, by use of pictograms on exits themselves, or through the available cabin safety instructions, in order to prevent opening of said exits in the event of outside hazards.**

4.6 Flight Recorders

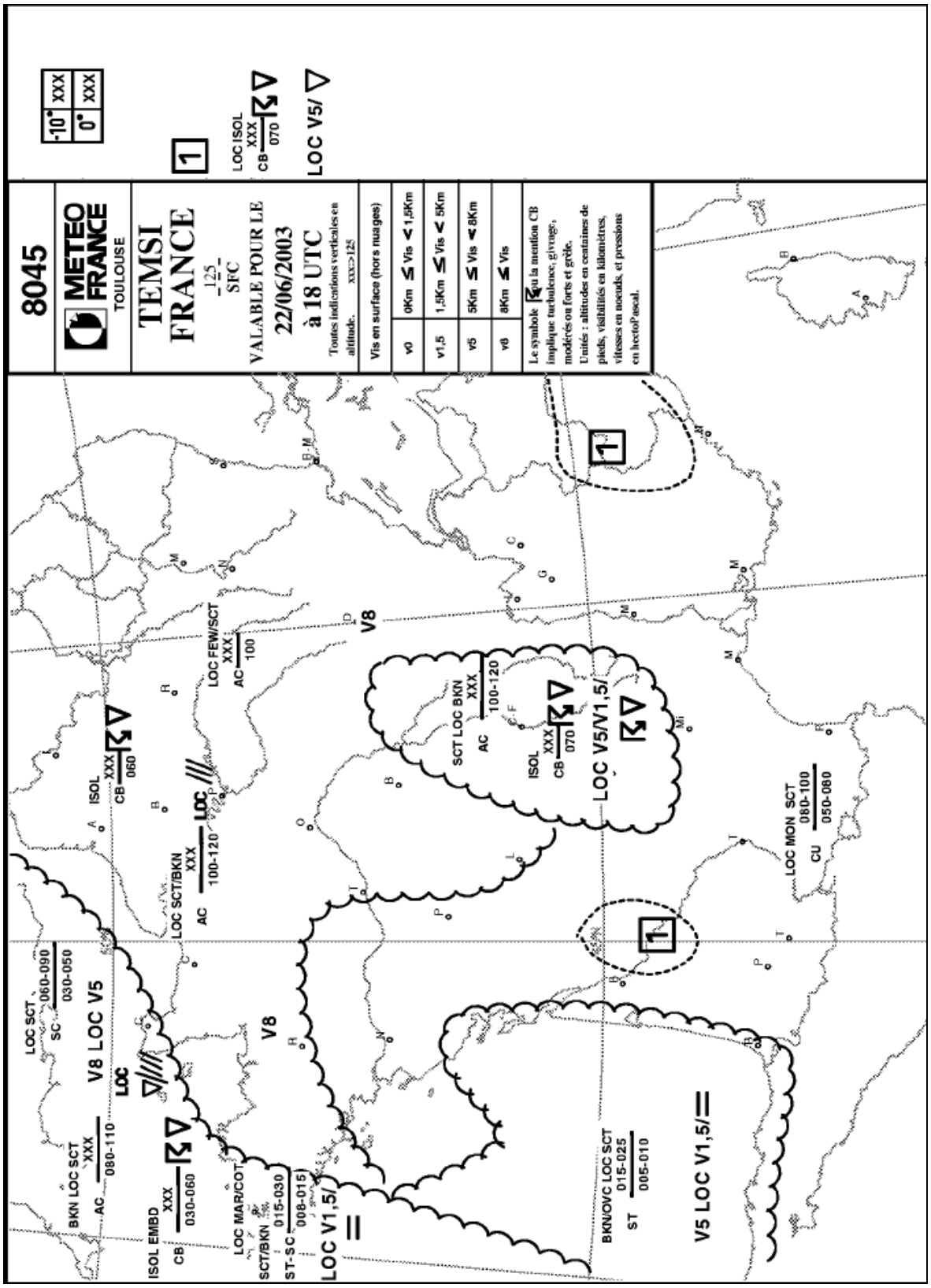
Exchanges in the cockpit were recorded solely on the cockpit area microphone. The poor quality of this recording did not enable a full reconstitution of cockpit communications.

Consequently, the BEA recommends that:

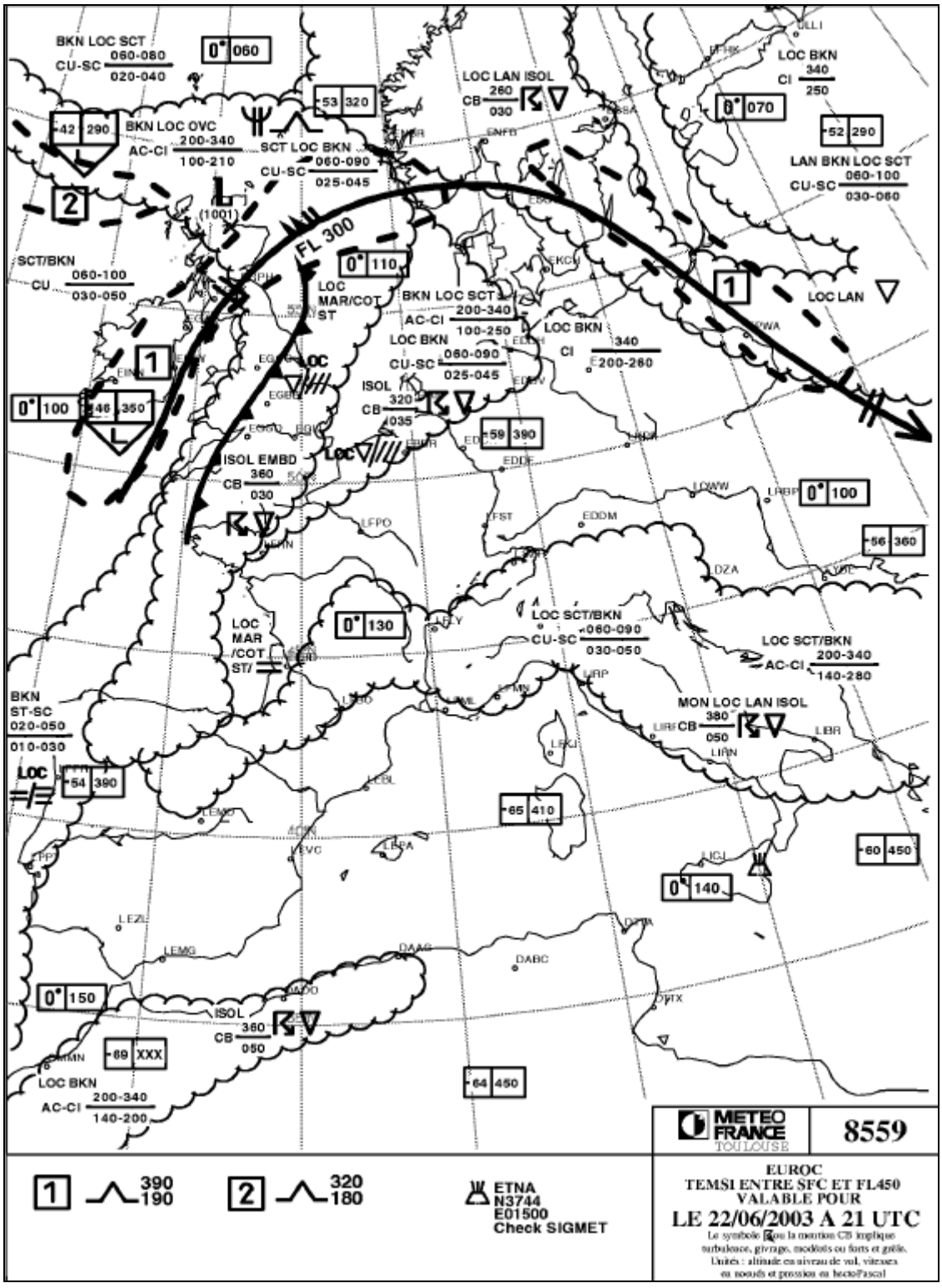
- **the DGAC impose the use of headset microphones in the climb and descent phases, or at the very least, below the transition level or altitude, in compliance with paragraph 6.20 of Annex 6 to the Convention on International Civil Aviation.**

List of Appendices

TEMSI chart - France at 18 h 00



TEMSI chart - Euroc at 21 h 00



Transcript of the Brest ATIS at 21 h 00

Transcript of ATIS for 22 June 2003

Début de l'enregistrement à 21 h 03 min 04 s

(illisible) Brest Guipavas information Tango enregistrée
Approche I L S 26 gauche.
Piste en service 26 gauche.
Niveau de transition 6 0 .
Approche de précision CAT 2 et CAT 3 hors service.
Piste secondaire fermée.
Vent 320 degrés 7 nœuds
Visibilité 800 mètres
Temps présent brouillard
Nuages Broken à 200 pieds
Scattered Cumulonimbus à 2 000 pieds
Température Plus 1 6 degrés
Point de rosée Plus 1 5 degrés
Q N H 1 0 0 7
Q F E 9 9 5

Informez Brest Guipavas dès le premier contact que vous avez reçu l'information Tango

(beginning of English-language version at 21 h 03 min 36 s)

This is Brest Guipavas information Tango recorded at 2 1 0 0 U T C time
I L S Approach 2 6 Left
Runway in use 2 6 Left
Transition Level 6 0
Caution; Precision approach CAT 2 and CAT 3 unserviceable
Secondary runway closed
Wind at 3 2 0 degrees 7 knots
Visibility 8 hundred meters
Present weather fog
Clouds Broken 2 hundred feet
Scattered C B at 2 thousand feet
Temperature Plus 1 6 degrees
Dew Point Plus 1 5 degrees
QNH 1 0 0 7
QFE 9 9 5

Inform Brest Guipavas on first contact you've received information Tango

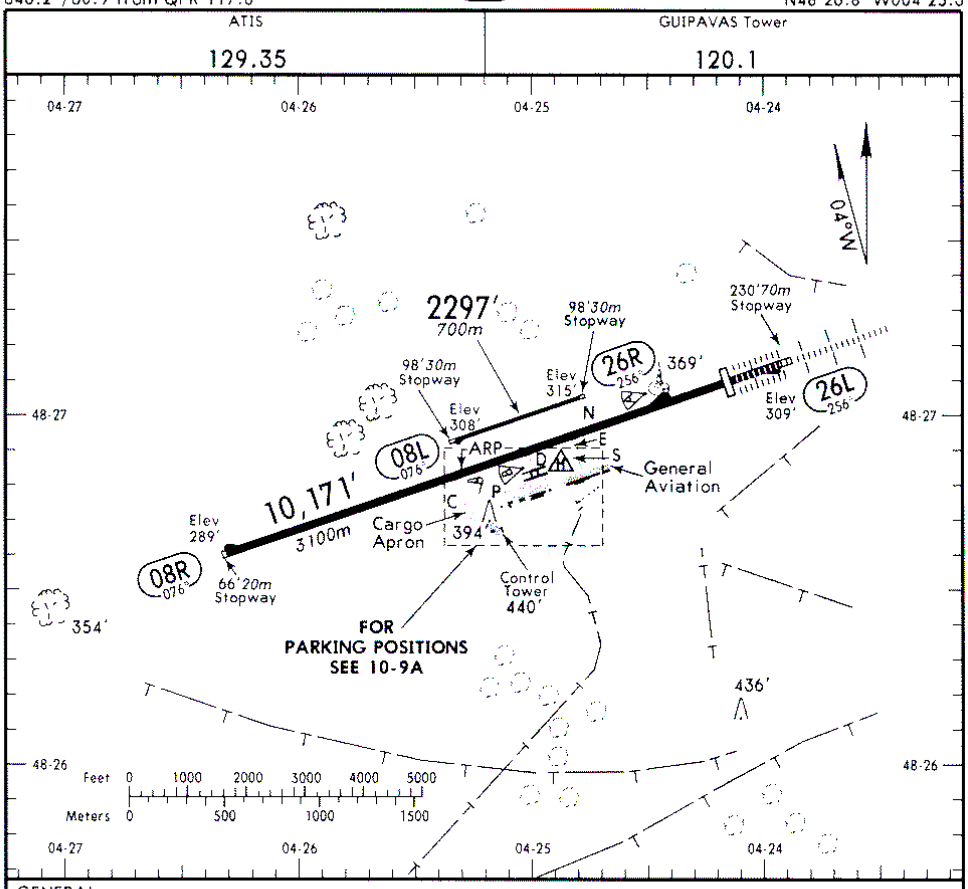
End of recording at 21 h 04 min 10 s

Jeppesen airport chart for Brest Guipavas

LFRB
Apt Elev 325′
346.2°/30.9 from QPR 117.8

JEPPESEN
12 JUL 02 (10-9)

BREST, FRANCE
GUIPAVAS
N48 26.8 W004 25.3



GENERAL
Rwy 26L is approved for CAT II/III operations, special aircrew and aircraft certification required.
180° turns on rwy for acft with length exceeding 131′ (40m) permitted on turning pads only.
Rwys 26L & 26R right-hand circuit .

ADDITIONAL RUNWAY INFORMATION

RWY		USABLE LENGTHS — LANDING BEYOND — Threshold	Glide Slope	TAKE-OFF	WIDTH
08L 26R					59′ 18m
08R	HIRL(60m) CL(15m) REIL PAPI-L(3.0°) VIBAL				148′ 45m
26L	HIRL(60m) CL(15m) HIALS TDZ PAPI-L(3.0°)RVR	9186′ 2800m	8284′ 2525m		

PREFERENTIAL RUNWAY SYSTEM: If not directed otherwise and wind speed is less than 2 m/sec, use rwy 26L or 26R.

JAR-OPS — TAKE-OFF [1]

	Rwy 26L LVP must be in Force Approved Operators HIRL, CL & mult. RVR req	Rwy 08R/26L LVP must be in Force RL, CL & mult. RVR req	RL & CL	RCLM (DAY only) or RL	RCLM (DAY only) or RL	NIL (DAY only)
A	125m	150m	200m	250m	400m	500m
B						
C						
D	150m	200m	250m	300m		

[1] Operators applying U.S. Ops Specs: CL required below 300m; approved guidance system required below 150m.

CHANGES: Variation.

CVR Transcript

Foreword

The following is a transcript of elements which were comprehensible, at the time of the preparation of the present report, on the cockpit voice recorder. This transcript contains conversations between crew members, radiotelephonic messages between the crew and Air Traffic Control services and various noises corresponding , for example, to the use of controls or to the alarms.

The reader's attention is drawn to the fact that the recording and transcript of a CVR are only a partial reflection of events and of the atmosphere in a cockpit. Consequently, the utmost care is required in the interpretation of this document.

The voices of crew members are heard via the cockpit area microphone (CAM). They are placed in separate columns for reasons of clarity. Two other columns are reserved for other voices, noises and alarms also picked up by the CAM.

Glossary

UTC time	UTC time recorded on the CVR through the FSK signal
CAM	Cockpit area microphone.
Control	Controller on the frequency used. The same column also includes ATIS messages [ATIS:], communications from the ground crew [ground:] and those from another aircraft [Charter 801:].
PF	Pilot flying
PNF	Pilot not flying
CPT	Captain
CP	Co-pilot
CC	Cabin crew
SV	Aircraft synthetic voice
➔	Communications outgoing to ATC, ground, and CC by interphone
(?)	Communication which it was not possible to attribute to one crew member
(…)	Words or parts of conversation having no bearing on the flight
( )	Words or groups of words in parentheses are doubtful
(*)	Word or group of words not understood

UTC time	PF (Captain)	PNF (Co-pilot)	Controlle	Other
20 h 48 min 02 s	**Beginning of recording**			
20 h 48 min 07 s				Single Chime
20 h 49 min				Passenger disembarkation
20 h 52 min				Cockpit noises, inaudible discussion,
21 h 02 min 15 s	We've had the flight plan (*) three sixty-nine with two two three			
21 h 02 min 20 s		Yes		
21 h 02 min 24 s	The clearance (*)… (*) level			
21 h 02 min 28 s	(Eleven hundred) the ZAC			
21 h 02 min 31 s	(?) (*)			
21 h 02 min 36 s				Noise of selector followed by a cabin gong
21 h 02 min 40 s	(?) (We've changed to second)			
21 h 02 min 44 s	(?) (So … there) (*)			
21 h 02 min 47 s	(?) (*)			
21 h 02 min 52 s		F min S		
21 h 02 min 53 s	(?) (*)			
21 h 02 min 53 s		Departure check		
21 h 02 min 54 s	Complete			
21 h 02 min 55 s		Landing elevation		
21 h 02 min 57 s	Three hundred and forty feet			
21 h 02 min 58 s			ATIS: Temperature plus Two Zero dew point One Eight QNH One Zero Zero Five Q F E One Zero Zero Two (*) threshold Zero Three One Zero Zero Three (*)Romeo Information. This is Nantes information Romeo information recorded at twenty-one hundred hours … runway in service zero three procedure N D B I L S… Transition level sixty … wind one nine zero degrees five knots visibility ten kilometres rare clouds eleven hundred feet Temperature twenty dew point eighteen Q N H one zero zero	
21 h 03 min 08 s	(?) (One Zero Zero Five) (*)			

UTC time	PF (Captain)	PNF (Co-pilot)	Controlle	Other
			five Q F E one two zero zero Q F E zero three thousand	
21 h 03 min 57 s	We could perhaps keep that			
21 h 03 min 58 s		Okay		
21 h 03 min 59 s	Yeah yeah			
21 h 04 min 00 s	(?) (Do you have a time) (*)			
21 h 04 min 01 s	(?) (Okay)			
21 h 04 min 03 s	(?) (You must have got too close to the power supply)			
21 h 04 min 44 s				Cabin Crew: Can we board?
21 h 04 min 44 s	Yeah… Yeah yeah			
21 h 05 min 03 s	(?) (So, you saw how to get positioned compared with the seven four seven)			Passengers boarding
21 h 05 min 11 s	(?) (*) (Come forward … great)			
21 h 05 min 54 s	(?) (*)			
21 h 06 min 04 s	Oh I won't go fast that way we'll have (*) then we will have two … two A (J) R			
21 h 06 min 09 s	(?) (*)			
21 h 06 min 22 s		And so we have two A (J) R		
21 h 06 min 52 s		Just while I (*) it or not… (*)		
21 h 06 min 55 s	(?) (*)			
21 h 06 min 57 s		Yeah		
21 h 07 min 00 s	(?) (*)			
21 h 07 min 06 s				Cabin Crew: Ready to depart whenever …
21 h 07 min 07 s	(?) (*)			
21 h 07 min 10 s	(…)			
21 h 07 min 16 s	So we have … twenty-one			
21 h 07 min 20 s	Eighteen tons nine hundred and forty-five			
21 h 07 min 25 s	With a (Take Off failure) (seven)… and there's no special details			
21 h 07 min 32 s		Ok		
21 h 08 min 01 s		Is there a push there?		
21 h 08 min 02 s	Yes…	Yes		
21 h 08 min 04 s	(…)			
21 h 08 min 11 s		➔ (Nantes good evening Brit Air six seven two Echo Charlie station six with information… Romeo and departure for Brest		
21 h 08 min 21 s	(?) (She is…)			
21 h 08 min 22 s			Echo Charlie cleared	

UTC time	PF (Captain)	PNF (Co-pilot)	Controlle	Other
			for taxi report for pushback allow for a (*) uh… would you like twenty one?	
21 h 08 min 31 s		➔ Yes please		
21 h 08 min 32 s			Roger, will give you twenty- one so RIMON nine Sierra and report when ready for pushback	
21 h 08 min 37 s		➔ Roger thank you very much for RIMON nine Sierra and we'll report when ready for pushback Brit Air uh… Echo Charlie		
21 h 08 min 41 s	She thinks you (*) Starting up?			
21 h 08 min 43 s		Uh one thousand uh…		
21 h 08 min 45 s	(?) (Shall we do the start-up checks?)			
21 h 08 min 46 s	(Obtained)			
21 h 08 min 47 s		Papers?		
21 h 08 min 47 s	Aboard			
21 h 08 min 47 s		Takeoff parameters?		
21 h 08 min 48 s	Displayed			
21 h 08 min 49 s		Hydraulic pump?		
21 h 08 min 49 s	Auto ON			
21 h 08 min 50 s		Parking brake?		
21 h 08 min 51 s	OFF			
21 h 08 min 51 s		Beacon?		
21 h 08 min 52 s	(ON)			
21 h 08 min 53 s		Fuel pump (gravity) X flow quantity		
21 h 08 min 54 s	Tested ON (*)			
21 h 08 min 56 s		Doors		
21 h 08 min 56 s	Closed			
21 h 08 min 57 s		Pack and bleed		
21 h 08 min 57 s	OFF			
21 h 08 min 58 s		And ignition		
21 h 08 min 59 s	ON			
21 h 09 min 03 s		➔ (so OK) Brit Air Echo Charlie we are ready for pushback		
21 h 09 min 06 s			Cleared for pushback report back when ready to taxi twenty one	
21 h 09 min 09 s		➔ We'll push back and report to taxi twenty one		
21 h 09 min 11 s	➔ (*) Good evening doors closed hold closed aircraft clear?			
21 h 09 min 14 s			Ground: Affirmative	
21 h 09 min 17 s			Ground: doors are closed handles in	

UTC time	PF (Captain)	PNF (Co-pilot)	Controlle	Other
			housings the (*) is in place	
21 h 09 min 21 s	➔ Parking brake off		Ground: (*) released	
21 h 09 min 23 s	we can push back for uh … we can push back		am starting pushback	
21 h 09 min 26 s	➔ Ready to start number two?			
21 h 09 min 28 s			Ground: Affirmative standing by for number two	
21 h 09 min 31 s		Ah… (*)		
21 h 09 min 34 s	(*)			
21 h 09 min 35 s			Ground: (*) positive	
21 h 09 min 37 s	(Are you maintaining) zero six on your side?			
21 h 09 min 39 s	(?) (Eh?)			
21 h 09 min 39 s		I have eight, my side		
21 h 09 min 40 s	(?) (Yes)			
21 h 09 min 42 s	Zero five?			
21 h 09 min 43 s		Yeah yeah		
21 h 09 min 46 s	And opening up… (*)			Noise similar to engine starting
21 h 09 min 46 s	(?) (*)			
21 h 09 min 55 s	(?) (*)			
21 h 09 min 57 s	Cue			
21 h 10 min 00 s		Start OFF		
21 h 10 min 00 s	➔ Ready to start number one (?)			
21 h 10 min 02 s			Ground: Standing by for number one	
21 h 10 min 05 s		Ignition (one)		
21 h 10 min 06 s		And left start		
21 h 10 min 07 s	N2?			
21 h 10 min 09 s			Ground: fan positive	
21 h 10 min 13 s	N1			
21 h 10 min 19 s	Opening up			Noise similar to engine starting
21 h 10 min 30 s	Fifty-five			
21 h 10 min 30 s		And starters OFF		
21 h 10 min 32 s	(*)	(*)		
21 h 11 min 09 s			Ground: pushback complete	
21 h 11 min 11 s	➔ Parking brake on			
21 h 11 min 12 s			Ground: Parking brake positive we're unhooking	
21 h 11 min 15 s	Yes callout	Electrical circuit gen.		
21 h 11 min 16 s	And checking			
21 h 11 min 17 s		Ignition		
21 h 11 min 18 s	OFF			
21 h 11 min 18 s		APU		
21 h 11 min 18 s	ON			
21 h 11 min 19 s		Pack		
21 h 11 min 19 s	ON			
21 h 11 min 20 s		Anti Ice		
21 h 11 min 20 s	(Tested OFF)			

UTC time	PF (Captain)	PNF (Co-pilot)	Controlle	Other
21 h 11 min 21 s		(Probes)		
21 h 11 min 21 s	ON			
21 h 11 min 21 s		ADG		
21 h 11 min 22 s	(Tested)			
21 h 11 min 22 s		Flight controls		
21 h 11 min 23 s	(*) down			
21 h 11 min 23 s		On the right you've still got nose wheel steering and clear perimeter		
21 h 11 min 34 s	➔ Operations from			
21 h 11 min 37 s	Juliet Sierra for Nantes for Brest		Ground: The bar is off and torque link is central	
21 h 11 min 40 s	➔ Thank you goodnight see you later		Ops: Received, over	
21 h 11 min 41 s			Same to you and have a good flight	
21 h 11 min 44 s	➔ Block zero five… twenty-one hours zero five with fifty minutes at ninety-three			
21 h 11 min 49 s			Ops: That's right have a good flight and see you later	
21 h 11 min 51 s	➔ See you later			
21 h 11 min 54 s	And steering is armed			
21 h 11 min 59 s	OK one second… Oh f… (*)	It's cleared		
21 h 12 min 04 s	(?) (We'll open up)			
21 h 12 min 07 s		➔ Uh Brit Air Echo Charlie ready for taxi to runway twenty one		
21 h 12 min 16 s	(?) (There's a downturn)			
21 h 12 min 19 s			Echo Charlie taxi to holding point Fox twenty one	
21 h 12 min 23 s		➔ Taxiing to holding point Fox twenty one		
21 h 12 min 32 s		And out of block		
21 h 12 min 35 s	Shall we prepare the briefing?			
21 h 12 min 36 s		Yes		
21 h 12 min 37 s	We'll take off at agreed weight of twenty uh nineteen tons… (Speed one hundred and ninety) Flaps twenty			
21 h 12 min 43 s		Yes		
21 h 12 min 44 s	If (*) problem after V1 (*) one hundred and nineteen (*) it will be V2 one hundred and thirty-			

UTC time	PF (Captain)	PNF (Co-pilot)	Controlle	Other
	three (We'll climb) standard to level sixty (and if we have) a problem radar return zero three (*)			Spurious loud noise
21 h 12 min 53 s		Yes		
21 h 12 min 54 s	Takeoff N1 reduced APU OFF			
21 h 12 min 55 s		No special points		
21 h 12 min 56 s	Okay			
21 h 12 min 58 s	(*)	(*)		
21 h 12 min 59 s		Flaps		
21 h 13 min 00 s	Twenty			
21 h 13 min 00 s		Trims		
21 h 13 min 01 s	Two green on (trim)			
21 h 13 min 02 s		Thrust reversers		
21 h 13 min 03 s	Armed			
21 h 13 min 03 s		(B T M S)		
21 h 13 min 03 s	Checked			
21 h 13 min 04 s		(Flight instruments)		
21 h 13 min 06 s	Checked			
21 h 13 min 07 s		And takeoff briefing		
21 h 13 min 08 s	Performed			
21 h 13 min 15 s		➔ A transponder please for Brit Air Echo Charlie?		
21 h 13 min 22 s			Brit Air Echo Charlie display fifty-one zero one	
21 h 13 min 28 s		➔ Fifty-one zero one and for the RIMON nine Sierra .. uh .. Echo Charlie		
21 h 13 min 33 s			That's correct and report when ready one hundred and eighteen sixty-five	
21 h 13 min 37 s		➔ Will report when ready eighteen sixty-five Echo Charlie		
21 h 13 min 50 s				Whistling noises
21 h 14 min 02 s	Ladies and Gentlemen good evening welcome aboard takeoff for Brest cloudy weather en route forecast sixteen degrees on arrival thirty minutes flight time thank you and hope you enjoy the flight and sorry for the delay… Good evening			
21 h 14 min 18 s	(?) (*) (It's alright, eh?)			
21 h 14 min 21 s	(?) Mmm?			
21 h 14 min 21 s	(?) (*)			

UTC time	PF (Captain)	PNF (Co-pilot)	Controlle	Other
21 h 14 min 25 s	(?) Yeah… (*)			
21 h 14 min 26 s		(?) (*)		
21 h 14 min 27 s	((*) zero five)	(*)		
21 h 14 min 30 s		The (…) left that has… that is too heavy		
21 h 14 min 33 s	Ah yeah there's something up			
21 h 14 min 34 s		Mmm…		
21 h 14 min 35 s	It's bizarre			
21 h 14 min 48 s				Cabin crew: (*) cabin ready
21 h 14 min 49 s	Thank you			
21 h 14 min 50 s		➔ Brit Air Echo Charlie on .. uh .. eighteen sixty-five we are ready		
21 h 14 min 55 s			Brit Air Echo Charlie cleared for lineup and takeoff on runway twenty one … one hundred and fifty degrees five knots	
21 h 15 min 03 s		➔ We are lining up and taking off on runway twenty one Echo Charlie		
21 h 15 min 08 s		Cabin crew report		
21 h 15 min 09 s	Obtained			
21 h 15 min 10 s		Transponder		
21 h 15 min 11 s	Alt			
21 h 15 min 12 s		Radar		
21 h 15 min 13 s	OFF			
21 h 15 min 13 s		Lights and strobes		
21 h 15 min 14 s	ON			
21 h 15 min 15 s		X flow auto override		
21 h 15 min 16 s	Manual			
21 h 15 min 17 s		The CAS		
21 h 15 min 17 s	Checked	(*)		
21 h 15 min 20 s		(?) (*)		
21 h 15 min 25 s				Spurious loud noise
21 h 15 min 26 s		We're cleared		
21 h 15 min 27 s	Take off completed (*) at V1			
21 h 15 min 29 s		(?) (*)		
21 h 15 min 30 s	(A hundred and nineteen and it is fifteen)			
21 h 15 min 40 s	(Are we ready for takeoff?			
21 h 15 min 41 s		Yes		
21 h 15 min 47 s		(?) (*)		
21 h 15 min 53 s		Flex displaying parameters in the green (AP armed)		
21 h 15 min 57 s		Eighty knots…		

UTC time	PF (Captain)	PNF (Co-pilot)	Controlle	Other
21 h 15 min 58 s		Cue		
21 h 15 min 58 s	It's checked			
21 h 16 min 07 s		V1		
21 h 16 min 08 s		VR		
21 h 16 min 13 s		Vertical speed positive		
21 h 16 min 14 s	Gear to up			
21 h 16 min 16 s	(?) (*)			
21 h 16 min 17 s	(?) (*)			
21 h 16 min 29 s	(?) (*) (Cabin Crew)			
21 h 16 min 30 s	(?) Yes			
21 h 16 min 43 s	The ZAC (off)			
21 h 16 min 44 s	(?) (*)			
21 h 16 min 54 s		The flex is confirmed		
21 h 16 min 56 s	OK			
21 h 16 min 59 s	Ah… we're going to put the radar on maybe in any case there seems to be some …			
		Okay		
21 h 17 min 02 s	Looks like there's some flashguns going off over there …			
21 h 17 min 11 s				Heavily attenuated signal for approx. one minute
21 h 17 min 25 s	(?) Ah yeah seems to be a fair old line of them… eh?			
21 h 17 min 28 s	(?) (Well anyway) (*)		Echo Charlie identified climb to level eleven zero	
21 h 17 min 32 s		➔ Climbing to level eleven zero Echo Charlie		
21 h 17 min 35 s	(?) (It's come up to eleven zero) (*)			
21 h 17 min 40 s	Yes… there you go			
21 h 17 min 40 s	(V T) flaps to (*)			
21 h 17 min 44 s	(?) (*) flaps to eight			
21 h 17 min 49 s	(?) ( ) flaps to zero			
21 h 17 min 52 s	(?) (*) Standard?			
21 h 17 min 53 s	(?) Yes			
21 h 17 min 53 s	(?) (*) (thirty-seven)			
21 h 17 min 57 s	Cue			
21 h 17 min 58 s		(It's number one)		
21 h 18 min 00 s		(*)		
21 h 18 min 01 s	Yeah			
21 h 18 min 02 s		I've put the time…		
21 h 18 min 03 s	Yes			
21 h 18 min 11 s		Landing gear		
21 h 18 min 12 s	Retracted			
21 h 18 min 13 s		Flaps		
21 h 18 min 13 s	Zero			
21 h 18 min 14 s		Altimeters		
21 h 18 min 15 s	Checked compared			

UTC time	PF (Captain)	PNF (Co-pilot)	Controlle	Other
	standard			
21 h 18 min 16 s		Thrust reversers		
21 h 18 min 17 s	OFF			
21 h 18 min 17 s		X flow auto override		
21 h 18 min 18 s	Auto			
21 h 18 min 18 s		APU bleed		
21 h 18 min 19 s	Bleed (ON) APU OFF			
21 h 18 min 21 s		No smoking		
21 h 18 min 22 s	Auto			
21 h 18 min 23 s		and the CAS		
21 h 18 min 23 s	(it's) checked			
21 h 19 min 27 s			Brit Air Echo Charlie contact Brest one hundred and eighteen decimal thirty-five goodbye	
21 h 19 min 31 s		➔Eighteen thirty-five good night		
21 h 19 min 38 s		➔ Brest good evening Brit Air six seven two Echo Charlie climbed to eleven zero initial		
21 h 19 min 44 s			Uh Echo Charlie… good evening climb to Level one eight zero direct BODIL	
21 h 19 min 49 s		➔ One eight zero direct BODIL		
21 h 19 min 54 s	One eight zero OK			
21 h 20 min 04 s		Have you got BODIL?		
21 h 20 min 05 s	Yes BODIL is OK			
21 h 20 min 08 s	One hundred and climbing			
21 h 20 min 09 s		Yeah		
21 h 20 min 11 s		Shall we leave them on?		
21 h 20 min 12 s	Oh… Yeah (it's OK)			
21 h 21 min 04 s		Are you keeping number one?		
21 h 21 min 05 s	I have number one			
21 h 21 min 15 s			ATIS: (*) one six degrees dew point one five degrees QNH one zero zero seven Q F E nine nine five… (*) information Tango. (*) information Tango recorded at two one zero zero UTC time I L S Approach 2 6 Left Runway in use 2 6 Left	

UTC time	PF (Captain)	PNF (Co-pilot)	Controlle	Other
			Transition Level 6 0 Caution; Precision approach CAT 2 and CAT 3 unserviceable Secondary runway closed Wind at 3 2 0 degrees 7 knots Visibility 8 hundred meters Present weather fog Clouds Broken 2 hundred feet Scattered C B at 2 thousand feet Temperature Plus 1 6 degrees Dew Point Plus 1 5 degrees QNH 1 0 0 7 QFE 9 9 5 Inform Brest Guipavas on first contact you've received information	
21 h 21 min 58 s		Did you hear that?		
21 h 21 min 59 s	No			
21 h 22 min 03 s		It's come back		
21 h 22 min 04 s	Nothing new			
21 h 22 min 05 s		So… ILS twenty-six Left		
21 h 22 min 07 s	Yeah			
21 h 22 min 09 s		Eight hundred meters visibility		
21 h 22 min 10 s	Really			
21 h 22 min 11 s		Fog… Broken two hundred		
21 h 22 min 13 s	OK			
21 h 22 min 15 s	Bizarre weather, that			
21 h 22 min 16 s		Cunimb above … a thousand and seven		
21 h 22 min 21 s	(Yeah)			
21 h 22 min 38 s	We'll start a bit higher maybe to uh… to be above those cells (there) (?) two twenty?			
21 h 22 min 42 s	We'll be fine	Okay		
21 h 22 min 45 s		➔ Brest from Brit Air Echo Charlie could we have two twenty to be above the cunimb?		
21 h 22 min 50 s			Affirm Echo Charlie climb to Flight Level two two zero	
21 h 22 min 53 s		➔Two two zero and		

UTC time	PF (Captain)	PNF (Co-pilot)	Controlle	Other
		climbing now Echo Charlie thank you		
21 h 22 min 56 s	Two two zero checked thank you	OK		
21 h 23 min 10 s				Whistling noise
21 h 23 min 29 s		➔And… Brit Air Echo Charlie could we have freedom of manoeuvre for … the heading?		
21 h 23 min 34 s			Uh Affirm Echo Charlie	
21 h 23 min 36 s		Thank you		
21 h 24 min 38 s				Singing
21 h 24 min 45 s	Autopilot engaged speed two… ten			
21 h 24 min 47 s		Yeah		
21 h 25 min 13 s				Altitude alert
21 h 25 min 29 s		Still under that crap		
21 h 25 min 32 s	Ah yeah it's isolated cells, I reckon			
21 h 25 min 33 s		Yeah		
21 h 25 min 52 s	Airspeed two eighty displayed			
21 h 25 min 54 s		Check		
21 h 26 min 03 s		Reckon you should go right?		
21 h 26 min 08 s	Oh there's nothing on the …			
		Ah it was detected there		
21 h 26 min 12 s	(?) (Okay?)			
21 h 26 min 30 s		(*)		
21 h 27 min 28 s	By the time …(*)			
21 h 27 min 29 s		Yeah		
21 h 27 min 59 s			Charter 801: Brest uh… for Charter eight zero one hello	
21 h 28 min 01 s	What time was that			
21 h 28 min 02 s	info?		France Charter eight zero one hello direct	
21 h 28 min 03 s		Twenty-one hundred	BODIL… and	
21 h 28 min 04 s			descend to level two	
	(*)		three zero initial	
21 h 28 min 10 s			Charter 801: two three zero initial	
			France Charter eight zero one	
21 h 29 min 42 s			France Charter eight zero one descend to level seven zero	
21 h 29 min 49 s			Charter 801: To seven zero eight zero one	
21:30 H min 05 s			Charter 801: Eight zero we would like to turn right forty degrees to avoid	

UTC time	PF (Captain)	PNF (Co-pilot)	Controlle	Other
21:30 H min 09 s			(*) Roger go ahead eight zero one	
21 h 32 min 06 s	Yeah			
21 h 32 min 06 s		The speeds are entered		
21 h 32 min 20 s		We should be able to get the VOR		
21 h 32 min 25 s	There's the runway			
21 h 32 min 25 s	(Right I'll do a circuit, now I won't say any more)			
21 h 32 min 33 s	Down there we're off to be in it			
21 h 32 min 35 s		Yeah		
21 h 32 min 42 s		➔Uh… Brit Air Echo Charlie we are uh… on heading three fifty to avoid a wall of cunimb		
21 h 32 min 48 s			OK no problem Echo Charlie	
21 h 32 min 58 s		What is R P again?		
21 h 33 min 00 s	Radius			
21 h 33 min 01 s			France Charter eight zero one descend to level six zero	
21 h 33 min 04 s			Charter 801: (For) six zero eight zero one	
21 h 33 min 10 s	(Ah…)			
21 h 33 min 11 s	That's a nice wall (there)			
21 h 33 min 12 s		Yes		
21 h 33 min 29 s		They don't come up very high here, what do you think?		
21 h 33 min 32 s	No			
21 h 33 min 33 s	Because they were forecast at three eighty over there … further			
21 h 33 min 35 s		Yeah		
21 h 34 min 29 s			Charter 801: (*) Charter eight zero one we are aligning you on the heading for BODIL Roger France Charter eight zero one. So … please contact Iroise one thirty-five eight two goodbye	
21 h 35 min 24 s		(*) put the approach on?		
21 h 35 min 26 s	Yeah do we have to do the approach?	Uh		
21 h 36 min 16 s	We could ask for the descent			

UTC time	PF (Captain)	PNF (Co-pilot)	Controlle	Other
21 h 36 min 17 s		Yes		
21 h 36 min 17 s	For a standard I L S (*) eleven one			
21 h 36 min 19 s	Displaying three three eight and five two zero			
21 h 36 min 22 s		Yes		
21 h 36 min 24 s		➔Brit Air Echo Charlie we would like to start our descent		
21 h 36 min 27 s			Roger Brit Air Echo Charlie descend to level one five zero	
21 h 36 min 32 s		➔ Descending to level one five zero .. uh ..… Echo Charlie		
21 h 36 min 36 s		Arrival briefing		
21 h 36 min 37 s	Complete			
21 h 36 min 40 s		So the parameters I have entered the V T		
21 h 36 min 43 s		for you the V 2 min D A five twenty on the right	Uh Brit Air Echo Charlie could you reduce your speed? you are number two behind a France Charter .. uh .. who is leaving one three zero on descent to Guipavas	
21 h 36 min 52 s		➔ Roger we are reducing .. uh .. we will reduce to two hundred … uh a slow reduction to two five zero knots		
21 h 37 min 00 s			Okay thank you	
21 h 37 min 02 s		Pressure?		
21 h 37 min 03 s	(It is) checked			
21 h 37 min 05 s		The CAS?		
21 h 37 min 05 s	Checked			
21 h 37 min 09 s		Central altimeter?		
21 h 37 min 10 s	Checked (at) one zero zero seven			
21 h 37 min 12 s		H C P		
21 h 37 min 15 s	three hundred and twelve three degrees checked			
21 h 37 min 16 s		Yeah		
21 h 37 min 24 s		OK, I'll just say a word behind about the descent?		
21 h 37 min 31 s		Ladies and gentlemen we are commencing our descent to Brest. Weather in Brest is foggy with a temperature of		

UTC time	PF (Captain)	PNF (Co-pilot)	Controlle	Other
		sixteen degrees (we are) currently avoiding a storm pattern… hope you have enjoyed the flight thank you		
21 h 38 min 48 s		It's crazy 'cause there you see the ground …		
21 h 38 min 50 s	Yeah			
21 h 38 min 51 s		And in Brest there's fog		
21 h 38 min 52 s	(*) it's really strange weather			
21 h 38 min 59 s			Uh… Brit Air Echo Charlie (*) with Iroise one thirty-five eighty-two good evening	
21 h 39 min 04 s		➔ Thirty-five eighty-two good night		
21 h 39 min 05 s			Sorry it's zero seven zero	
21 h 39 min 08 s		➔ Could you repeat for Echo Charlie?		
21 h 39 min 10 s			Yes so Brit Air Echo Charlie descend level seventy seven zero and with Iroise one thirty-five eighty-two goodbye	
21 h 39 min 17 s		➔ (*) one thirty-five eighty-two to level seven zero good night		
21 h 39 min 23 s		➔ Iroise good evening Brit Air six seven two Echo Charlie descending to level seven zero .. uh ..… for BODIL while avoiding storms		
21 h 39 min 31 s			Brit Air Echo Charlie descend four thousand feet QNH one zero zero eight number two on the approach allow for a holding pattern at Golf Uniform	
21 h 39 min 41 s		➔ Yes and so uh… we will reduce a little bit and so planning a holding pattern descending to four thousand feet QNH one zero zero eight .. uh ..… for Echo		

UTC time	PF (Captain)	PNF (Co-pilot)	Controlle	Other
		Charlie.		
21 h 39 min 51 s			That is correct	
21 h 39 min 55 s		(A thousand and eight)		
21 h 39 min 55 s	(*) four thousand so uh displaying a thousand and eight on the central will you read it fourteen thousand…			
21 h 40 min 05 s	Cue			
21 h 40 min 06 s		Check it's correct thirteen thousand eight… Cue		
21 h 40 min 10 s	Check			
21 h 40 min 11 s		Altimeter?		
21 h 40 min 12 s	Adjusted compared with QNH			
21 h 40 min 13 s		Landing elevation?		
21 h 40 min 14 s	Check three hundred and forty (*)			
21 h 40 min 21 s		Do you want to do the hundred eh?		
21 h 40 min 41 s	Two fifty-six (that it's in)			
21 h 40 min 45 s		Check		
21 h 40 min 47 s	One minute			
21 h 40 min 51 s		Yes		
21 h 40 min 52 s	(*)	(*)		
21 h 41 min 04 s	(Heading mode active) Nav mode selected			
21 h 41 min 07 s		Yes (*)		
21 h 41 min 12 s		Ah… start of the fog		
21 h 41 min 16 s		We're going to arrive Morlaix		
21 h 41 min 31 s		That is crazy … It can be thirty degrees… and two hours after there's fog		
21 h 41 min 38 s	(?) (*)			
21 h 41 min 40 s	Ah it's very… fast			
21 h 41 min 42 s		Yeah yeah		
21 h 41 min 45 s			Brit Air Echo Charlie reduce speed minimum clean	
21 h 41 min 49 s		➔ Roger will reduce speed minimum clean uh .. Brit Air Echo Charlie		
21 h 41 min 53 s		(He must be)… ten nautical in front of us		
21 h 41 min 57 s		Can't he move it … what type of aircraft is he		
21 h 42 min 01 s	A charter (* a) thirty-seven			

UTC time	PF (Captain)	PNF (Co-pilot)	Controlle	Other
21 h 42 min 02 s		Yeah but uh… isn't he moving (the seven thirty-seven)		
21 h 43 min 00 s	(Speed min) one eighty			
21 h 43 min 03 s		Yes		
21 h 43 min 32 s		Shall we prepare the five thousand?		
21 h 43 min 35 s	We can			
21 h 43 min 35 s				Noise of selector followed by cabin gong
21 h 43 min 39 s				Noise of selector
21 h 43 min 43 s			Charter 801: Established on the Loc uh… France Charter eight zero one	
21 h 43 min 46 s			Zero one continue the approach report when over Outer Marker	
21 h 43 min 49 s			(Charter 801): Report over Outer Marker eight zero one	
21 h 43 min 52 s		(…)		
21 h 44 min 21 s			(Brit Air) Echo Charlie descend to three thousand feet QNH one zero zero eight and perform a holding pattern the fog has descended over the field I'm not going to have you …. I won't be able to let you approach right away	
21 h 44 min 33 s		➔ Okay well then we'll hold then uh .. descending to three thousand feet … for Echo Charlie		
21 h 44 min 41 s			That's correct	
21 h 44 min 41 s				Noise of selector
21 h 44 min 42 s	Three thousand displayed			
21 h 44 min 43 s		Yeah		
21 h 44 min 44 s	(*)			
21 h 44 min 48 s	Right well in that			
21 h 44 min 49 s	case we'll have to do it we're doing a Cat 2, right ?			Noise of selector
21 h 44 min 52 s		Cat Two and Cat Three are prohibited		
21 h 44 min 54 s	Ah yes that's right no			

UTC time	PF (Captain)	PNF (Co-pilot)	Controlle	Other
	more Cat Two Cat Three			
21 h 44 min 56 s		Yes		
21 h 44 min 58 s	Yeah it was just for the … the ceiling			
21 h 44 min 59 s				Noise
21 h 45 min 01 s	Yeah anyway it's nighttime … we'll see			
21 h 45 min 03 s		Yeah		
21 h 45 min 05 s		Exactly		
21 h 45 min 15 s	Three hundred and twenty-seven knots			
21 h 45 min 24 s				Altitude alert
21 h 45 min 26 s	One thousand			
21 h 45 min 27 s		One thousand ahead		
21 h 45 min 30 s				Noise of selector
21 h 45 min 38 s	(?) (*)	(*)		
21 h 45 min 42 s			Charter eight zero one cleared for landing on twenty-six left three one zero degrees nine to fifteen knots the runway is wet, cloud base at two hundred feet	
21 h 45 min 50 s		We've got an hour's wait		
21 h 45 min 51 s			(Charter eight zero one): We're landing on twenty six left France Charter eight zero one	
21 h 45 min 54 s	Cloud base two hundred		RVR runway threshold one thousand three hundred meters at mid-runway eight hundred meters	
21 h 45 min 58 s			(Charter eight zero one): Roger	
21 h 45 min 59 s		(A game)		
21 h 46 min 05 s				Noise
21 h 46 min 06 s		A game from my nephew		
21 h 46 min 14 s				Noise similar to cockpit door opening
21 h 46 min 15 s				Cabin Crew: The cabin is ready
21 h 46 min 17 s	Sixteen degrees			
21 h 46 min 18 s				Cabin Crew: OK
21 h 46 min 18 s	We're doing a little circuit			
21 h 46 min 19 s				Cabin Crew: We're doing a

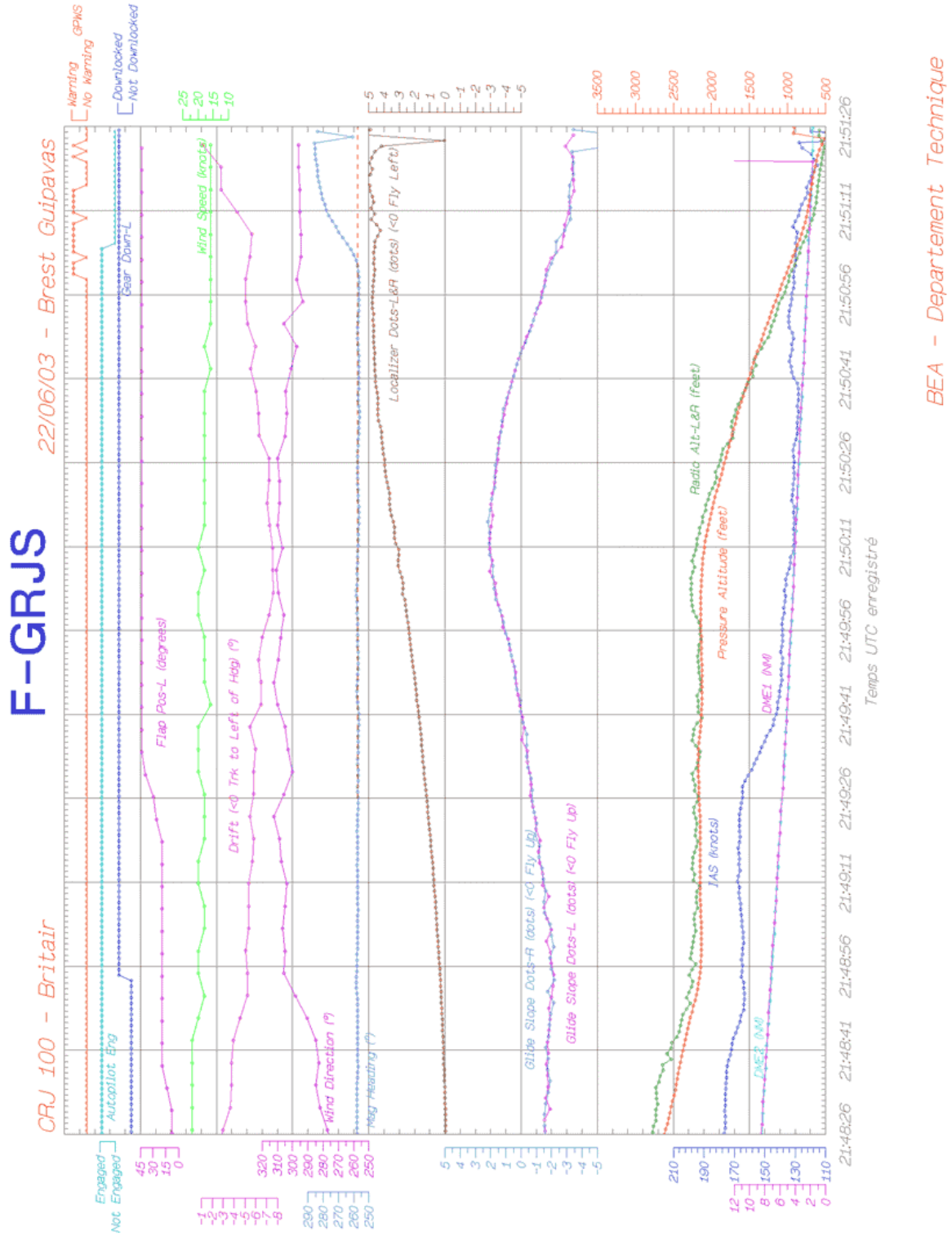
UTC time	PF (Captain)	PNF (Co-pilot)	Controlle	Other
				little circuit?
21 h 46 min 20 s		Yeah		
21 h 46 min 20 s	An aircraft in front yeah			
21 h 46 min 24 s				Noises similar to those of a door
21 h 46 min 26 s				
21 h 46 min 35 s				Increase in background noise
21 h 46 min 40 s		Flight spoilers are retracted yes		
21 h 47 min 07 s	(Two hundred) flaps to eight for comfort			
21 h 47 min 09 s		Yeah		
21 h 47 min 11 s		Flaps to eight		Noise similar to moving of flap control
21 h 47 min 40 s			Echo Charlie descend two thousand feet QNH one zero zero eight	
21 h 47 min 43 s		➔ Descending to two thousand feet QNH one zero zero eight… … Echo Charlie		
21 h 47 min 49 s				Noise
21 h 47 min 51 s				Altitude alert
21 h 47 min 53 s	Two thousand one thousand eight			
21 h 47 min 54 s		Yeah		Reduction in background noise
21 h 48 min 01 s			Echo Charlie the aircraft in front has landed continue the approach report at Outer Marker	
21 h 48 min 07 s		➔ (OK) Will report at outer marker uh… and we continue on the centreline Echo Charlie		
21 h 48 min 12 s				Noise
21 h 48 min 13 s	So I've selected VOR mode			
21 h 48 min 15 s		Yes		
21 h 48 min 16 s	(great)			
21 h 48 min 17 s		Yes		
21 h 48 min 18 s			Echo Charlie?	
21 h 48 min 19 s		➔ Echo Charlie over		
21 h 48 min 21 s			Are you ready for the approach ?	
21 h 48 min 22 s		➔ Affirmative		
21 h 48 min 23 s			Report at outer marker	
21 h 48 min 24 s		➔ We will report at		
21 h 48 min 26 s	She didn't receive it	outer marker Echo		

UTC time	PF (Captain)	PNF (Co-pilot)	Controlle	Other
		Charlie		
21 h 48 min 29 s	So speed flaps to twenty			
21 h 48 min 31 s		Yes yes the flaps to twenty		Noise similar to movement of flap control
21 h 48 min 34 s			(*) zero one exit Charlie then Papa	
21 h 48 min 38 s	Speed gear to down			
21 h 48 min 40 s		Yes… gear to down		
21 h 48 min 40 s				Noise similar to extension of the landing gear followed by an increase in background noise
21 h 48 min 42 s			Charter eight zero one it'll be the next on the right	
21 h 49 min 00 s	ALT S CAP			
21 h 49 min 02 s		Yeah… check		
21 h 49 min 14 s	Speed flaps at thirty			
21 h 49 min 17 s		Below one eighty five flaps to thirty		
21 h 49 min 19 s				Noise similar to movement of flap control
21 h 49 min 23 s	Flaps to forty-five and after that the check (approach)			
21 h 49 min 26 s		Flaps to forty-five uh… Cabin attendant check		
21 h 49 min 28 s	Confirmed			
21 h 49 min 29 s		Go-around altitude?		
21 h 49 min 31 s	Two thousand displayed			
21 h 49 min 31 s		Gear?		
21 h 49 min 32 s	Down three greens			
21 h 49 min 33 s		Flaps?		
21 h 49 min 33 s	Forty-five			
21 h 49 min 34 s		Thrust reversers?		
21 h 49 min 35 s	Armed			
21 h 49 min 35 s			Brit Air Echo Charlie cleared for landing on twenty-six left three two zero degrees eight to fifteen knots cloud base now below one hundred feet	
21 h 49 min 45 s		➔ Roger so uh…		
21 h 49 min 49 s		we're landing on runway twenty six left uh… Echo Charlie		Two consecutive noises
21 h 49 min 51 s			And the RVR's eight hundred meters and	

UTC time	PF (Captain)	PNF (Co-pilot)	Controlle	Other
			nine hundred meters	
21 h 49 min 54 s		➔ Roger		
21 h 49 min 56 s		(oh damn we didn't..)		
21 h 49 min 58 s		… (*)		
		(Approach) (*)		
21 h 50 min 00 s			Charter eight zero one can you see the marshaller?	
21 h 50 min 03 s	(?) (*)			
21 h 50 min 06 s			Charter eight zero one: Yeah (affirm)	
21 h 50 min 07 s			(Call) the marshaller, goodnight	
21 h 50 min 08 s			Charter eight zero one, goodnight	
21 h 50 min 09 s		Ah (…)		
21 h 50 min 11 s	Oh didn't it catch it?			
21 h 50 min 14 s	Heading			
21 h 50 min 14 s	Fifteen hundred seventeen hundred it's okay	(*)		
21 h 50 min 17 s	Oh well we'll see eh			
21 h 50 min 19 s	(sixteen) hundred feet it's okay	Yes yes yes… exactly		
21 h 50 min 21 s		(It's OK)		
21 h 50 min 21 s		You're getting it back. Do you want me to put the approach on for you?		
21 h 50 min 24 s	Uh… no no that's what'll (take it), eh. We've got to get above?			
21 h 50 min 29 s	(Right, there we've gotta go) (*)			
21 h 50 min 32 s	(?) Fifteen hundred initial			
21 h 50 min 32 s	There it is, it's in			
21 h 50 min 43 s	There we are			
21 h 50 min 45 s	The approach is selected Loc and Glide			
21 h 50 min 48 s		Yes		
21 h 50 min 52 s		(*) you come right		
21 h 50 min 54 s	(Yes okay)	(Come back)		
21 h 50 min 56 s		(*) come right		
21 h 50 min 58 s				SV: Five Hundred
21 h 50 min 59 s				SV: Glide slope
21 h 51 min 02 s				SV: Sink Rate
21 h 51 min 04 s				SV: Sink Rate and alarm autopilot-disengage (for two seconds)
21 h 51 min 05 s				SV: Three Hundred
21 h 51 min 07 s				SV: Glide slope
21 h 51 min 08 s				SV: Glide slope

UTC time	PF (Captain)	PNF (Co-pilot)	Controlle	Other
21 h 51 min 09 s				SV: Glide slope
21 h 51 min 11 s		Yeah (*) go right		
21 h 51 min 11 s				SV: Glide slope
21 h 51 min 12 s	(Yeah)			
21 h 51 min 12 s				SV: Glide slope
21 h 51 min 13 s		Go right		SV: Glide slope
21 h 51 min 14 s				SV: Glide slope
21 h 51 min 15 s				SV: One Hundred
21 h 51 min 16 s		I've nothing in front		
21 h 51 min 16 s	Go around			
21 h 51 min 19 s		(?) Go around		
21 h 51 min 20 s				SV: Sink Rate
21 h 51 min 21 s				SV: Pull Up
21 h 51 min 22 s		(?) Go around		
21 h 51 min 22.75 s				Sound of impact
21 h 51 min 24.51 s	**End of recording**			

FDR graphs


F-GRJS
CRJ 100 - Britair
22/06/03 - Brest Guipavas
BEA - Departement Technique
Temps UTC enregistré
Warning
No Warning
GPWS
Downlocked
Not Downlocked
Gear Down-L
Flap Pos-L (degrees)
Wind Speed (knots)
Drift (<0 Trk to Left of Hdg) (°)
Wind Direction (°)
Hdg Heading (°)
Localizer Dots-L&R (dots) (<0 Fly Left)
Glide Slope Dots-R (dots) (<0 Fly Up)
Glide Slope Dots-L (dots) (<0 Fly Up)
Radio Alt-L&R (feet)
Pressure Altitude (feet)
IAS (knots)
DME1 (NM)
DME2 (NM)
Engaged
Not Engaged
Autopilot Eng
21:48:26
21:48:41
21:48:56
21:49:11
21:49:26
21:49:41
21:49:56
21:50:11
21:50:26
21:50:41
21:50:56
21:51:11
21:51:26

Emergency-beacon triggering curves

AIR PRECISION

5 AVENUE DENIS PAPIN BOÎTE POSTALE N°36
92353 LE PLESSIS ROBINSON CEDEX - FRANCE
Tél.: 01.46.01.21.15 Tlx:634093 Fax: 01.46.32.52.07

NOTE

The crash response curve of ELT96, according to ED62 (page 63).

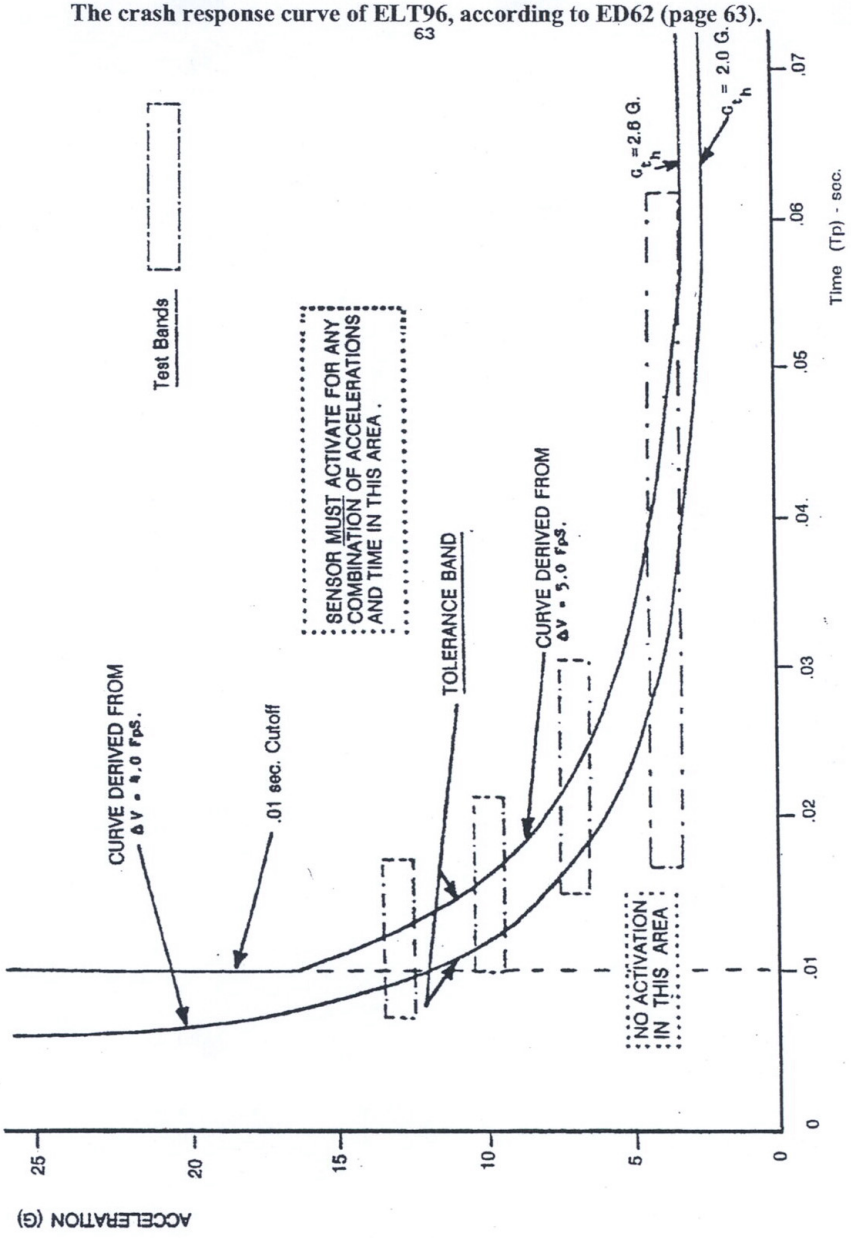


Figure 5-7 : Crash Sensor Response Curve

Scenarios of simulator sessions

All scenarios start at or near BODIL, at 3000 ft QNH.

The simulator is initialized with the following parameters:
- landing weight: 18,100 kg;
- fuel: 1900 kg (quantity remains constant throughout the simulation);
- CG position (MACLAW): 15.93;
- Vref: 132 kts;
- Vt (clean climb): 165 kts;
- V2GA: 139 kts;
- wind: 310°/15 kts.

Scenario 1

The crew performs the holding pattern (GU) on autopilot at 3000 ft. The autopilot active mode is NAV, and the source, FMS. Following the holding pattern, the crew is cleared for an approach and performs a Cat I ILS approach to RWY 26L in APPR mode, with selection of a MDA of 520 ft, and go-around at 90 ft radio altimeter height (flaps 45° then 8° in go-around).

Objectives

- visualize the MD and notably reproduction of the holding pattern;
- observe the transition from NAV mode to APPR mode and observe the associated actions;
- observe the GPWS announcements when a MDA is displayed;
- observe mode-changes on the FMA, the behaviour of the flight director, and more generally the PFD;
- observe arming of the APP mode inside the LOC capture beam;
- observe the behaviour of the flight simulator in go-around (flaps 8°): control forces and associated loss of altitude.

Observations

1. Holding pattern

The scenario starts at 3000 ft at BODIL. The NAV mode is active, the navigation source is FMS. On the FMA, the indications “FMS1” and “ALT” are displayed in green and the flight director is permanently centred. The holding pattern is displayed on the MD. The holding pattern is performed with the autopilot active.

Descent to 2000 ft: the altitude of 2000 ft is selected on the FCP. The SV mode is then activated by pressing the ‘SV’ button and selecting a vertical speed of –1000 ft/min.

2. Arming the approach

- ILS frequency 1 is activated; the navigation source is set for “VOR”. The autopilot then switches into ROLL mode. The HDG mode is then activated then the APPR mode is armed: LOC 1 and GS then blink in green on the FMA during capture then are displayed steady in green. The flight director remains centred throughout the approach.

NOTE: This sequence does not correspond precisely to the intended scenario. The HDG mode should have been activated prior to the change of NAV source. This explains the need to go through Roll mode.

- The “OM” indication flashes blue in the top right of the ADI on passing the Outer Marker.
- The indications “MDA 520” are displayed permanently on the right of the FMA, in blue. When traversing the MDA, the “MDA” indication is displayed flashing on the ADI, at the top right of the screen. Simultaneously, the GPWS announcement “Minimums Minimums” is heard.
- The APPR mode is activated immediately it is armed, and the FMA indicates “LOC” (green) on the left and “GS” (white) on the right, then “LOC” (green) and “GS” (green) on the left when the glide slope is captured.
- A diamond symbolizing the LOC appears at 600 ft radio altimeter height under the ADI. When it reaches the end of travel, the diamond becomes a half-diamond. The representation is the same for the glide slope. The main representation of the LOC is situated on the HSI with a green bar (with centre break) symbolizing the LOC axis, and a segment indicating deviations in respect of the axis.
- The autopilot is disengaged at 650 ft radio altimeter height.
- The go-around (flaps 8°) is started at 90 ft radio altimeter height. The TOGA button is engaged and the horizontal bar of the flight director adopts a +10° attitude. The symbols “GA GA” are displayed in green on the FMA.
- The minimal height during the go-around sequence is 60 ft, which represents a height-loss of 30 feet.

3. GPWS announcements

- “Five hundred”
- “Minimums minimums” at 520 ft QNH.
- “One hundred”

NOTE: The heights “400”, “300” and “200” were not heard during the simulation.

Scenario 2

The crew is cleared for a CAT I approach to RWY 26L. They immediately arm the HDG mode then the APPR mode. A DH of 200 ft is selected; the go-around takes place at 90 ft radio altimeter height.

NOTE: The DH is habitually displayed for CAT II and CAT III approaches.

Objectives:

- observe interception of the LOC by the APP mode, then interception of the glide slope;
- observe the difference in the MDA / DH displays and the associated GPWS announcements.

Observations:

1. First part

- The beginning of the simulation is performed under autopilot, in HDG mode. On the FMA, the “HDG” and “SV” indications are displayed in green, with the “ALT” indication in white. The approach is armed for between 0.7 and 0.9 points off the LOC, and capture never occurs. The SV mode is activated, with a vertical speed selection of -1000 ft/min. The FMA indicates: “HDG” “SV” “1,0” and “↓” in green, and “LOC 1”, “ALT S” and “GS” in white. The flight director remains centred throughout the approach.

NOTE: The scenario does not run as intended because the approach is armed belatedly and the aircraft drifts due to the wind. LOC capture does not take place and the descent is performed under AP, in HDG, SV mode. Since this scenario is close to the circumstances of the accident flight, it is not interrupted.

- The indication “DH 200” is displayed on the right of the FMA, in blue.
- During the descent, the aircraft is below the glide slope, and numerous GPWS “Glide Slope” announcements are heard. The announcements “Two hundred” then “One hundred” are also heard, but not the announcement “Minimums”. On the ADI, the glide and localizer are at the limit of travel, and on the HSI, the localizer reaches the end of travel at two points. The scenario is continued until the go-around.

2. Second part

- The scenario is picked up after arming of the APPR mode. A heading of 280° (convergent with the localizer beam centreline) is displayed on the heading selector. The indication “HDG 280” appears in the bottom left of the ADI. The FMA indicates “HDG” “ALT S” ands “HEADING” in green, and “LOC 1” and “GS” in white.
- At 1.3 points from the LOC, capture takes place. On the FMA, “LOC 1” flashes green, still with the indications “ALT S” and “HEADING” in green, and “GS” in white. 0.4 points from the glide slope, the “GS” symbol flashes green.
- The GPWS announcements “Five hundred”, “Minimums Minimums ” then “One hundred” are heard successively.

Scenario 3

The crew is cleared for a CAT I ILS approach to RWY 26L. The APPR mode is armed belatedly (outside the LOC beam capture envelope). The go-around is performed in the 45° configuration at 90 ft radio altimeter height.

Objectives:

- to replicate the accident flight;
- to observe the aircraft's drift in HDG mode;
- to replicate the go-around with flaps at 45°.

Observations

- The scenario starts at 3000 ft in proximity to BODIL. The crew steers on the FMS toward the GU marker beacon. On the FMA, the indications are: "FMS 1", "ALTS" and "HEADING" in green. 10 NM from BG, the crew descends toward 2000 ft QNH on the localizer beam centreline.
- The crew is cleared for approach: the HDG mode becomes active. The PF changes the navigation source from FMS to VOR and selects the ILS1 frequency. The indication on the left of the HSI changes from "FMS 1" to "LOC 1". At 2000 ft, the symbol "ALT S" flashes green on the FMA. The crew configure the aircraft for landing. The aircraft begins to drift toward the left. The aircraft is on the glide slope 5 NM from BG, still at 2000 ft QNH. The indication on the FMA is "HDG" and "ALT S" in green. The PF engages the SV mode, which recaptures instantaneously because the altitude selected is equal to the flight altitude (2000 ft). The PF selects a higher altitude (3600 ft) then engages the SV mode at a rate of 1500 ft/min. The displays on the FMA are "HDG", "SV" "1.5" and "↓" in green, and "ALT S" in white. Two points from the LOC, when the aircraft crosses the glide slope, the PF arms the APPR mode (display of "LOC 1" and "GS" indications in white on the FMA). The flight director remains centred continuously. At 340 ft the autopilot is disengaged, the vertical speed being -1100 ft/min.
- The PF initiates the go-around at 70 ft radio altimeter height. During the go-around procedure, the height-loss is 20 ft.
- GPWS announcements: several "Glide slope" then "Sink Rate" alarms, "Five hundred"… at 430 ft radio altimeter height, "One hundred" and no "Minimums" announcement at the MDA but a "Sink rate" alarm and the MDA symbol flashing yellow on the ADI.

Additional tests

Certain additional simulations allowed several points to be confirmed:

- Arming the APPR mode at 0.2 points to the left of the LOC with a divergent heading of about 15° resulted in capture of the localizer (green "LOC" on the FMA).
- Same test one point from the LOC: the LOC is not captured.
- With a slightly convergent heading (< 5°), the capture occurs about 0.6 point off the LOC.
- Go-around flaps 45° with engine thrust corresponding to 40% of N1: the go-around is started at 90 ft, the observed minimum altitude is 25 ft radio altimeter height.

NOTES:

- The simulator does not faithfully replicate control-input forces (notably during go-arounds).
- The GPWS announcements transmitted by the simulator are not representative of the announcements heard in flight in the aircraft.

Brest Guipavas Airspace

Iroise airspace:

- *Iroise TMA -- class E.*
- *Iroise SIV -- class E in the vertical limits of TMA and CTA air traffic controlled airspace areas. Class G all other areas.*

Airspace delegated by Brest:

- *outside of opening hours of Landivisiau, airspace area S/CTA 1 IROISE, S/CTA 3 IROISE and S/CTA 4 IROISE class E.*
- *outside of opening hours of Landivisiau and Lanvéoc, IROISE S/CTA 2 controlled areas (class E).*
- *Iroise CTA (class E).*

NOTE 1: During opening hours of Landivisiau and Lanvéoc, the above-mentioned S/CTA airspace areas are managed by Landivisiau and Lanvéoc in Class D.

NOTE 2: Iroise manages ceiling levels in the above-mentioned delegated airspace areas.

Note concerning LVP at Brest Guipavas

Guipavas, 29 April 2003

STANDING ORDER REF. 18/2003

Concerns: LVP Procedures
References: 020719 DACO/D2NB
Case Manager:

Direction de l'Aviation Civile Ouest

This Order cancels and replaces that dated 25 April 2003

At Brest-Guipavas, LVP procedures shall be implemented for the following meteorological conditions:

lowest measured RVR below 800 meters, or cloud base below 200 feet.

RVR below 400 meters for LOW-VISIBILITY TAKE-OFFS
(Runway 08 is not certified for take-offs with visibility under 150 meters).

IMPLEMENTING OF LVP

1 - Implementing of LVP shall be recorded on the ATIS.

2 - The backup generator must be operating throughout the duration of LVP.

3 - Lighting to be operating; status panel to be checked

4 – Manoeuvring area to be cleared 150 meters either side of runway centreline.

5 - ILS locked (Localizer and Glide-slope shelter doors closed, no maintenance in progress).

6 - Inform the aircraft rescue and fire-fighting department ("SSLIA") for inspection of runway and clearance of ILS critical/sensitive areas.

7 - Inform the BGTA department for increased surveillance of anti-intrusion means.

8 - Inform Maintenance Department and Electrical Department (office hours).

9 - RVR's must be communicated to pilots.

10 - Observe aircraft separation distances:
following an arrival, the second aircraft shall be cleared to commence its approach only when the runway is clear;
following a departure, the arriving aircraft shall be cleared to commence its approach only when the departing aircraft reports it has cleared the runway.

11 - Aircraft movements on the manoeuvring area shall be limited to one aircraft at a time.

12 - Push-back shall be authorized only if the aircraft can take off before the commencement of a CAT II or CAT III approach by the arriving aircraft.

13 - Inform the aircraft rescue and fire-fighting department ("SSLIA") of any temporary or permanent lifting of LVP conditions.

14 - Inform the BGTA department and the Maintenance Department and Electrical Department of permanent lifting of LVP conditions.

15 - The bird-scaring track lies within ILS-sensitive areas, therefore is not usable during LVP conditions (landings and take-offs) nor during CAT II and CAT III training periods.

(The above Standing Order is to be included in the Controller Operations Manual).

BUREAU D'ENQUETES ET D'ANALYSES
POUR LA SECURITE DE L'AVIATION CIVILE
Aéroport du Bourget - Bâtiment 153
93352 Le Bourget Cedex
FRANCE
Tél. : +33 1 49 92 72 00
Fax : +33 1 49 92 72 03
com@bea-fr.org

www.bea.aero / www.bea-fr.org

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