MINISTERE DE L'EQUIPEMENT DES TRANSPORTS ET DU LOGEMENT - INSPECTION GENERALE DE L'AVIATION CIVILE ET DE LA METEOROLOGIE - FRANCE

BEA

Serious incident on 23 November 1997 on approach to Orly (94) to the McDonnell Douglas MD83 registered F-GRMC operated by AOM Minerve S.A

REPORT

Translation

f-mc971123a

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 serious incident.

In accordance with Annex 13 of the Convention on International Civil Aviation, with EC directive 94/56 and with Law N° 99-243 of 30 March 1999, the analysis is 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 is the work of reference.

The original report in French contains technical information in the appendices that is referred to in this English translation of the body of the final report.

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Glossary

ADF	Automatic Direction Finder
ADI	Attitude Director Indicator
LOFT	Line Oriented Flight Training
AIP	Aeronautical Information Publication
AOL	All-Operator Letter
ATIS	Automatic Terminal Information System
BITE	Built In Test Equipment
CAWS	Central Aural Warning System
CENA	ATC Study Centre (Centre d'Etudes de the Navigation Aérienne)
CPEMPN	Flight Crew Medical Test Centre (Centre Principal d'Expertise Medical des Personnels Navigants)
AR	Activity Report
CRM	Cockpit Resource Management
CVR	Cockpit Voice Recorder
DA	Decision Altitude
DAC	Civil aviation directorate (Direction de l'Aviation Civile)
DFDAU	Digital Flight Data Acquisition Unit
DFGS	Digital Flight Guidance System
DGAC	General civil aviation directorate (Direction Générale de l'Aviation Civile)
DME	Distance Measuring Equipment
EFIS	Electronic Flight Instrument System
FAA	Federal Aviation Authority
FL	Flight Level
FDR	Flight Data Recorder
FGCP	Flight Guidance Control Panel
FMA	Flight Mode Annunciator
GPWS	Ground Proximity Warning System
CASG	Civil Aviation Safety Group
HSI	Horizontal Situation Indicator
IAC	Instrument Approach chart
IAF	Initial Approach Fix
IATA	International Air Transport Association
IFR	Instrument Flight Rules
ILS	Instrument Landing System
kt	Knots
LAA	Applied Anthropology Laboratory (Laboratoire d'Anthropologie Appliquée)
LVP	Low Visibility Procedure
METAR	Regular meteorological report for aircraft
MSAW	Minimum Safe Altitude Warning

NM	Nautical Mile
NOTAM	Notice to Airmen
NTSB	National Transportation Safety Board (USA)
ICAO	International Civil Aviation Organisation
FO	First Officer
OCV	In-flight inspection organisation (Organsime de Contrôle en Vol)
WMO	World Meteorological Organisation
AP	Automatic Pilot
PF	Pilot Flying
PFD	Primary Flight Display
PNF	Pilot Not Flying
P/N	Part Number
QAR	Quick Access Recorder
O.QAR	Optical Quick Access Recorder
OM	Outer Marker
QFU	Runway magnetic bearing
QNH	Altimeter setting to obtain aerodrome elevation when on the ground
RVR	Runway Visual Range
SFACT	Technical inspection and aeronautical training service (Service de Formation Aéronautique and du Contrôle Technique)
SIGMET	Significant Meteorological Message
S/N	Serial Number
SPECI	Special Observation Message
TAF	Terminal Area Forecast
TCAS	Terminal Collision Avoidance System
TMA	Terminal Control Area
TOP	Transoceanic and polar license
TRI	Thrust Rating Indicator
VMC	Visual Meteorological Conditions
VOR	VHF Omnidirectional Radio Range

ORGANISATION OF INVESTIGATION

AOM Minerve S.A. informed the BEA Duty Officer of the event on Thursday 27 November 1997 at around 16 h 00, four days after the incident. An investigation was immediately launched.

An Investigator-in-Charge and a Deputy Investigator directed the investigation.

Correspondents from the following assisted the BEA:

- AOM Minerve S.A.
- ADP
- the DGAC, (SFACT E-EP, DAC North and CENA)
- Météo France

An Accredited Representative from the NTSB and his technical advisors from the FAA and from Boeing, Douglas Product Division participated in the investigation.

Certain parts of the work were carried out by:

- The Applied Anthropology Laboratory (LAA, Paris)
- Raytheon, MD83 Flight Simulator Division, Great Britain.
- Allied Signal

SYNOPSIS

Date and time
23 November 1997 at 12 h 32 UTC[1]

Aircraft
McDonnell Douglas MD83 registered F-GRMC

Place of incident
On approach to runway 07 at Orly (94)

Owner
ORIX Altar Corporation
World Trade Centre
bul 4-1-Hamamatsu-Cho
2-Chome Minato-Ku
Tokyo

Type of flight
Scheduled domestic public transport flight.

Operator
AOM Minerve S.A.

Persons on board
3 Flight Crew
4 Cabin Crew
131 passengers

Summary

On final ILS approach, the Captain performed a go-around in Instrument Meteorological Conditions as the airplane was passing the Outer Marker. The minimum radio height during the go-around was sixty-seven feet.

Consequences

	PEOPLE			EQUIPMENT	THIRD PARTY
	KILLED	INJURED	UNHURT		
CREW	-	-	7	-	-
PASSENGERS	-	-	131		

[1]. All times in this report are UTC, except where otherwise specified. Two hours should be added to express official time in metropolitan France on the day of the serious incident.

1 - FACTUAL INFORMATION

1.1 History of the Flight

The evolution of the AOM Minerve scheduled domestic flight IW 68 was analyzed on the basis of flight documents, recorded data and witness statements.

On Sunday 23 November 1997, the crew flew the Toulon-Orly-Marseille route stages. On the previous day, they had flown the Orly-Nice-Orly-Toulon route stages. The crew consisted of a Captain instructor and two first officers (FO) on Line Oriented Flight Training (LOFT). The two FO's on LOFT occupied the co-pilot's and observer seats alternately.

The airplane, an MD83 registered F-GRMC, landed at Marseille at 10 h 35. During the preparation of the Marseille-Orly flight, the crew received a meteorological file. The alternate airport was Paris-Charles de Gaulle. The flight dossier indicated that the airplane was carrying 20,000 pounds of fuel. The Captain stated that he had loaded sufficient fuel in reserve to return to the South of France in case the meteorological conditions made a landing at Orly impossible.

At 11 h 25, the airplane took off from Marseille with 131 passengers and 7 crewmembers. The co-pilot was pilot flying. The flight took place without any notable events until the preparation of the approach to Orly. The autothrottle and autopilot 2 were connected throughout the flight.

The crew prepared category I, II and III precision approaches on runways 07 and 26 at Orly. At 11 h 53, Paris ATC announced RVR of 400 meters on runway 07. At 12 h 07 the Captain took over as pilot flying. At 12 h 14 min 43 s, the crew contacted Orly Approach which announced RVR of 500 meters.

At 12 h 26 min 23 s, the Captain selected track 258° on the VHF NAV 1 (left) instead of 065°, the correct approach track. The co-pilot did not check the display.

At 12 h 28 min 33 s, the Captain armed the "autoland" mode.

At 12 h 29 min 34 s, Orly Approach ended radar vectoring and transferred the airplane to the Tower controller at an altitude de 3,000 feet, at a speed of 160 kt, on heading 020° for interception of the runway 07 ILS.

The co-pilot had selected track 065° on the OL VOR. He announced that the airplane was crossing this track. At 12 h 29 min 43 s, the "LOC capture" mode appeared on the Flight Mode Annunciator (FMA). The Captain announced "LOC capture heading QFU" and, looking at the HSI, he brought the heading indicator to the tail of the ILS bar. He later stated that he thought at that time that he had brought the heading indicator to the head of the arrow and not to the tail. He then noticed that the heading indicated 078° while he expected the QFU of runway 07, that is to say 065°.

At 12 h 29 min 53 s, Orly Tower announced RVR of 400 metres.

Subsequently the Captain did not announce the actions he took relative to the automatic systems.

At 12 h 29 min 59 s, the Captain selected a 060° heading on the DFGS. At 12 h 30 min 01 s, he armed the "ILS" mode. At 12 h 30 min 03 s, the "LOC CAPTURE" mode appeared again on the FMA. At 12 h 30 min 07 s, the Captain selected the same heading of 060 on the "HEADING" mode. The heading increased progressively. The Captain requested that the landing gear be extended.

At 12 h 30 min 20 s, the airplane went above the approach track. At 12 h 30 min 29 s, the Captain armed the "ILS" mode. A 12 h 30 min 40 s, he armed the "autoland" mode, displayed an altitude of 2,000 feet, selected a descent speed of around 2,300 feet per minute and a heading of 090°.

The airplane came back towards the approach track and descended in clear skies.

The Captain then realized that he had selected an ILS heading of 258° instead of 065° and corrected it. A short time afterwards, Orly Tower indicated that the airplane was 1.5 NM north of the track.

The flaps were extended to 40° and the Captain selected the final approach speed. During this time, the airplane went below the glideslope track. Then, with the Captain’s authorization, the co-pilot selected the ILS on the right side, instead of the OL VOR.

From 12 h 31 min 26 s, at a radio height of 916 feet, the Ground Proximity Warning System (GPWS) "Glideslope" warning was recorded by the QAR. The airplane entered the fog at that moment or a few seconds later. During the descent, the pilot saw that the bar of the glideslope track was up against its stop and said "glide" twice. At 12 h 31 min 28 s, the Captain disconnected the autopilot.

At a radio-height of 783 feet, the "Terrain" warning was recorded for two seconds by the QAR. The "Glideslope" warning started up again as soon as the "Terrain" warning ended.

The Captain tried to bring the airplane back onto the approach track. At 12 h 31 min 43 s, the "LOC capture" mode appeared on the FMA again. At 12 h 31 min 49 s, the Captain re-connected the autopilot, at a radio-height of 415 feet. He then armed the "autoland" mode.

At a radio-height of 279 feet, the "terrain" warning was recorded again for a further nine seconds.

At 12 h 31 min 56 s, the Captain disconnected the autopilot and began a go-around. At that moment, the radio-height was about 200 feet. At 12 h 32 min 09 s, the minimum radio-height of 67 feet and the Outer Marker signal were recorded. The co-pilot would state that he saw the ground and read a radio-height of about 50 feet.

The go around and the runway circuit were performed with radar vectoring. The landing took place in "autoland" mode. The airplane landed at Orly at 12 h 45.

1.2 Injuries to Persons

Not applicable.

1.3 Damage to Aircraft

There was no damage to the aircraft.

1.4 Other Damage

Not applicable.

1.5 Personnel information

1.5.1 Flight Crew

1.5.1.1 Captain

- Male, 52 years old.

- Certificates and licenses
  - Commercial Pilot's License on 25 February 1971.
  - First Class Commercial Pilot's License on 14 February 1974.
  - Air Transport Pilot's License with TOP on 17 January 1990, license valid until 30 April 1998.
  - Last medical check-up at the CPEMPN (Paris) on 31 October 1997.

- Type Ratings
  - Type ratings for MS733, ND26, C337, PA23, PA34, BE80, BE58, BN2, C310, FK27, DC8, DC8/70, MD80, FA22/27, B737-300/400/500 and B737-200.
  - MD83 type Rating on 30 April 1991
  - Reduced Category I precision approach certificate on 10 March 1995.
  - Precision approach category II and III rating on 4 September 1995.
  - Minimum operational standards course on 28 June 1997.
  - Skills maintenance course on 10 October 1996.
  - Human Factors revision course in May 1996.
  - CRM instructor course on 8 and 9 April 1997.
  - Standard CRM course on 27 August 1997.
  - Line check on 14 October 1997.
  - Base check on 17 January 1997.

- Instructor Officer rating on 30 November 1992, valid until 31 March 1999.

- Aeronautical career
  - Instructor at the UTA air club from February 1971 to May 1973.
  - Technical Officer and Chief Pilot of BE58 and BE90 at Thalass Air Quiberon from March 1974 to October 1974.
  - Captain of ND26 and FO FK27 at Lina Congo from December 1974 to June 1975.
  - Captain on FK27 at S.F.A.H. (Nouméa) from June 1975 to October 1976.
  - First Officer on DC8/63 at Air Zaïre from December 1977 to October 1978.
  - Captain of DC8 at African Safari Airways from October 1978 to March 1991.
  - Captain of MD83 at Jet Alsace/Trans Alsace (Basle) from April 1991 to June 1994, instructor from November 1992 and head of MD83 wing from May 1993.
  - Captain and instructor on B737/200 at Air Pacific from October 1994 to December 1994.
  - Captain of B737 at E.B.A. from January to February 1995.
  - Captain and instructor on B737/200 at Air Pacific from November to December 1995.
  - Captain of MD83 for AOM Minerve S.A. since the March 1 1995 on an unlimited-term contract.
  - Assigned to Air Toulouse on B737's in September 1996 and January 1997.

- Experience
  The following flying hours were provided by AOM Minerve SA and were confirmed by the Captain.
  - Total flying hours: 17,800
  - As Captain: 10,000
  - As Captain on MD83: 3,000
  - Flying hours in the previous 6 months: 548
  - Flying hours in the previous 3 months: 290
  - Flying hours in the previous 30 days: 115
  - Flying hours as air club instructor: 2,500 to 3,000
  - Flying hours as ground /simulator instructor: around 600

- First Officers trained: 20 to 30

- Inspector at Air Méditerranée for B737 type rating until April 1997.

- Flying hours in the year previous to the incident: see appendix 1.

1.5.1.2 Co-Pilot on LOFT

- Male, 30 years old.

- Certificates and licenses
  - Commercial Pilot's License on 15 May 1991, valid until 31 October 1998.
  - Practical test for the Air Transport Certificate on 10 September 1993.
  - Human factors course certificate in December 1996, issued on

1 January 1997.
- Theoretical section of Air Transport Pilot's License in March 1992 valid until June 2004.
- Last medical at the CPEMPN (Paris) on 3 October 1997.

- Qualifications
  - IFR rating on 15 May 1991 valid until 30 June 1998.
  - BE90 type ratings, equivalence BE100 and BE200.
  - MD83 rating on 14 November 1997 (first QT JAR25).
  - After completing the type rating, he was authorized to undertake reduced category I landings.

- Aeronautical career
  - FO on BE90 for Oyonnair, then FO on BE200 for Transport Air Centre on charter flights from June 1991 to June 1992.
  - Joined AOM Minerve S.A in January 1993. As traffic supervisor until beginning of MD83 training on 6 October 1997.
  - Unlimited term sub-contract with AOM Minerve S.A.

- Training
  - The co-pilot on LOFT followed the SFACT PFE certified training program 7.18.90 from 16 September 1997.
  - He followed all of the simulator training periods on MD83 with electro-mechanical instrumentation.
  - He had undertaken eight LOFT flights with an FO as backup.

- Experience
  The following flying hours are taken from the co-pilot on LOFT logbook and end at the end of the incident flight.
  - Total flying hours: 490 h 44
  - As Captain: 235 h 46
  - Flying hours on multi-engined aircraft: 167 h 59 of which 28 h 33 as Captain
  - Flying hours in the previous 30 days: 52 hours of flight simulator and the flights described in the table in appendix 1.

Note: The flying hours taken from AOM Minerve S.A.'s Activity Report, which are shown in the table in appendix 1, are different. The flying hours really performed are calculated in chapter 1.16 "Tests and Research".

1.5.1.3 Co-pilot on LOFT in observer seat

- Female, 25 years old.

- Certificates and licenses
  - Commercial Pilot's license on 5 February 1996, valid until 30 September 1998.
  - Certificates obtained towards Air Transport Pilot's License: T in September 1994, then Meteorology, R, EB, EA, FH in September 1996, English for Air Transport Pilot's License in March 1997.
  - Had not obtained the following qualifications at that time: NAV, TOP and

DA.
- Last medical at the Toulouse CEMPN on 18 September 1997.

- Qualifications
  - IFR rating du 22 October 1996 valid until 28 February 1998.
  - Successive type ratings on B737-500 on 28 February 1997 (first QT JAR25 and B737-300 and 400 equivalence) and SAAB 2000 on 30 May 1997.
  - MD83 rating on 14 November 1997.
  - Having obtained the airplane type rating, she was authorized to undertake reduced category I landings.

- Aeronautical career
  - FO on SB 2000 for Regional Airlines from April 1997.
  - In this context, she had undertaken four flights in the observe seat as backup crew member. The role of a backup crew member is to provide backup to the crew during the first flights of co-pilots on LOFT.
  - Employed on an unlimited-term contract by AOM Minerve S.A since 6 October 1997, the beginning of her MD83 training.

- Training
  - The co-pilot on LOFT followed the SFACT PFE certified training program 7.18.90 from 16 September 1997. She followed all of the simulator training periods on MD83 with electro-mechanical instrumentation.
  - Only her first LOFT flight was undertaken with an FO as backup.

- Experience
  The following flying hours are taken from the co-pilot on LOFT's logbook and end at the end of the incident flight.
  - Total flying hours: 602 h 45
  - As Captain: 152 h 17
  - Flying hours on multi-engined aircraft: 335 h 22 of which 2 h 15 as Captain
  - Flying hours in the previous 30 days: 52 hours of flight simulator and the flights described in the table in appendix 1.

Note: The flying hours taken from AOM Minerve S.A.'s Activity Report, which are shown in the table in appendix 1, are different. The flying hours really carried out are calculated in chapter 1.16 "Tests and Research".

1.5.2 Tower Controller in LOC position

- Female, 42 years old.

- Qualifications:
  - First Controller, valid until 31 December 1999,
  - Team Leader.

- Medical Aptitude valid until 14 February 1999.

- Qualified for the LOC position.

1.6 Aircraft Information

The aircraft was airworthy. It was equipped to perform category III precision approaches and there were no acceptable deferred defects for the flight in question.

The airplane performed an auto-approach to Orly a few minutes after the incident. A month after the incident, the airplane continued to fly without any problems occurring.

Aircraft

- Manufacturer: McDonnell Douglas (USA)
- Type: DC 9-83 (MD83)
- Serial number: 53466
- Registration: F-GRMC
- Entry into service on 23 December 1994.
- Airworthiness certificate issued on 23 December 1994, renewed on 4 December 1997, valid until 22 December 2000.
- Flying hours as of 23 November 1997: 7 104 hours, 5 628 cycles
- Since last major overhaul on 14 October 1997: 287 hours, 239 cycles.

Engines

- Manufacturer: Pratt and Whitney (USA).
- Type: JT8D-219.

Onboard Equipment

- The airplane is equipped with an Electronic Flight Instrument System (EFIS). On each pilot's instrument panel, there is a Primary Flight Display (PFD) and a Navigation Display (ND). The armed modes on the FMA are amber in colour, the other modes being green (autothrust, roll and pitch modes).

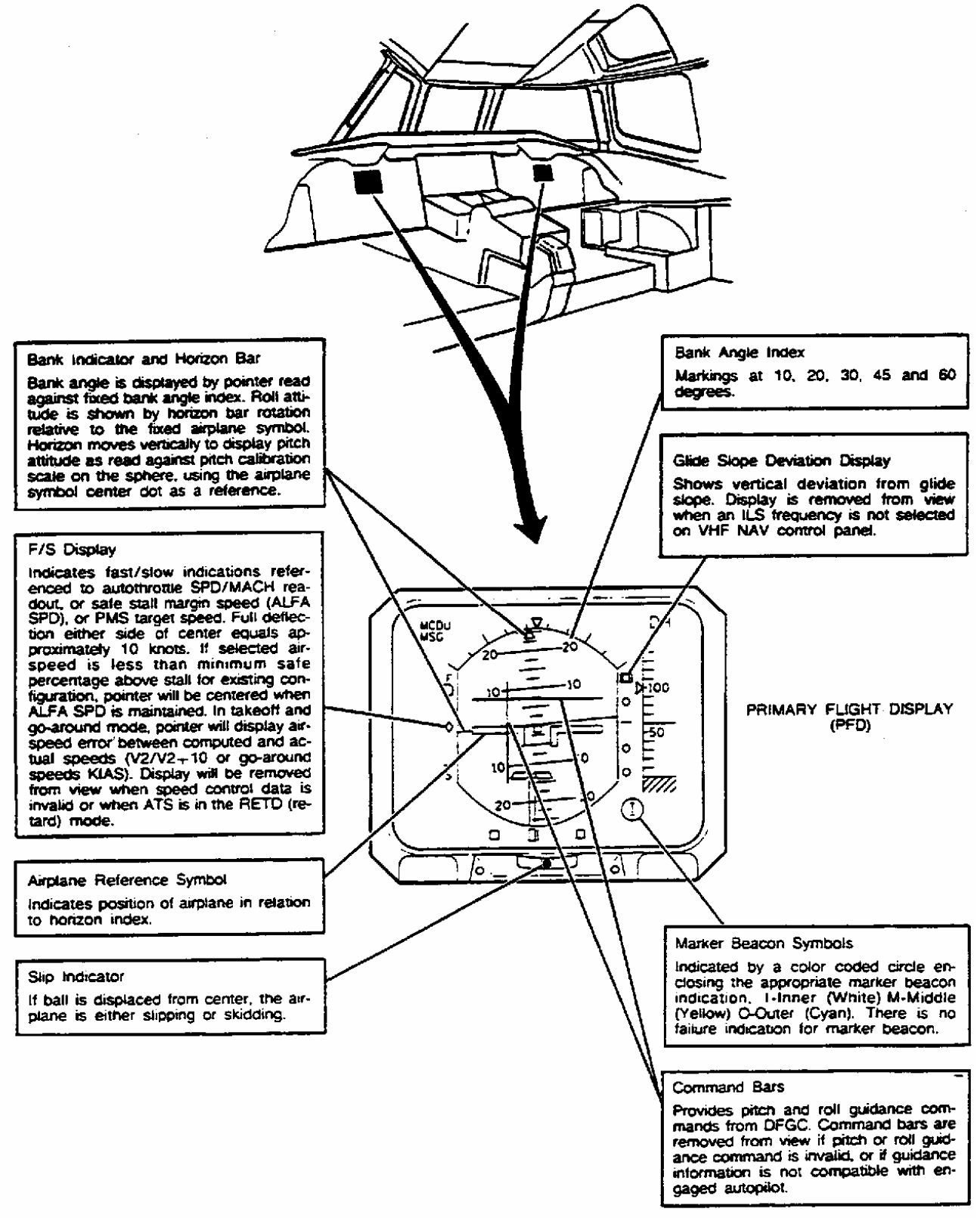


Figure 1 – Description of the PFD as shown in the Operating Manual

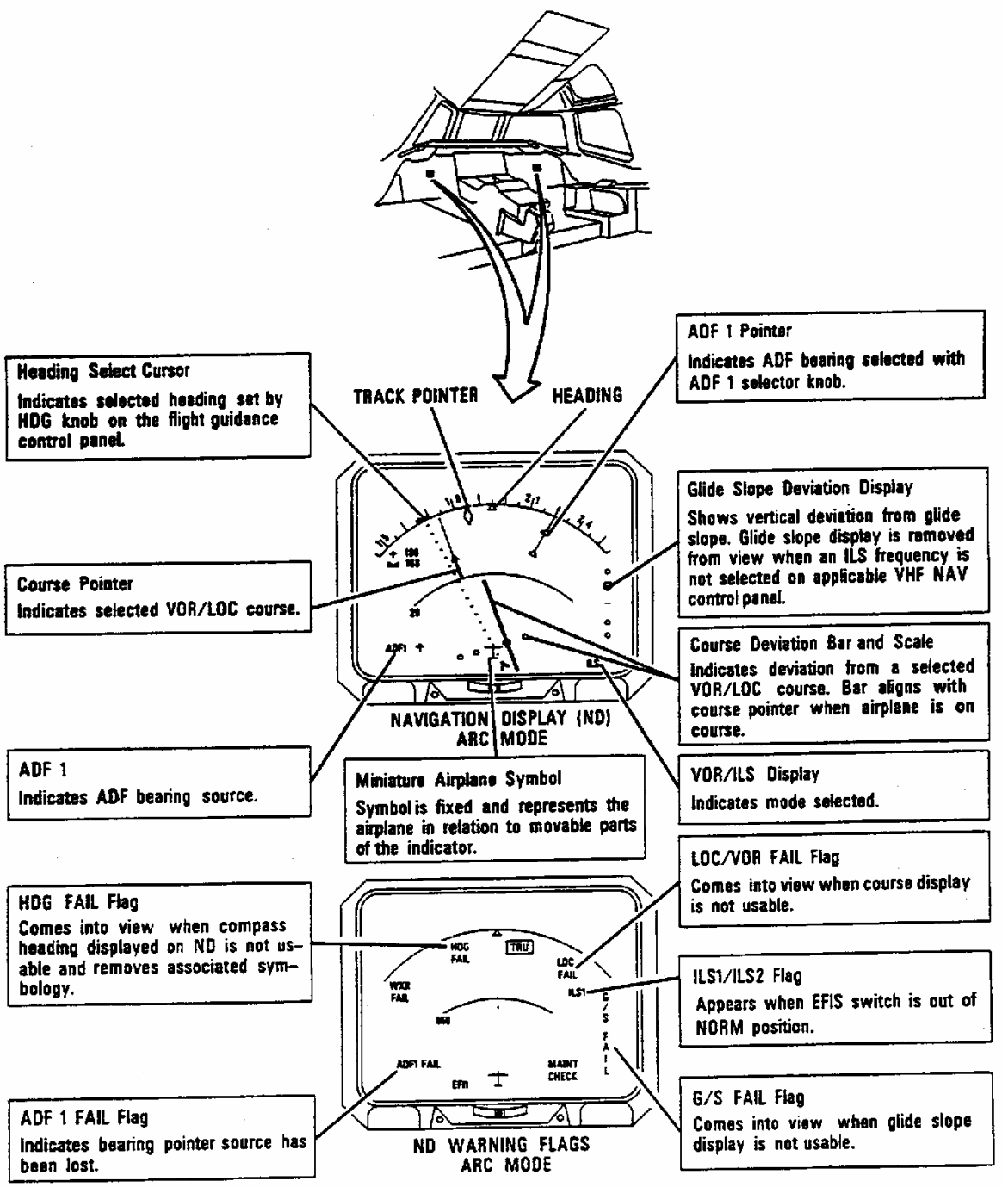


Figure 2 - Description of the ND in ARC mode as shown in the Operating Manual

- The airplane is equipped with an Allied Signal Mark VII GPWS (P/N 965-0876-030, S/N 2269) whose main characteristics and main alarms are as follows:
  - mode 1: excessive sink rate, "Sinkrate" and "pull up" warning,
  - mode 5: descent below the glideslope track, normal and strong "Glideslope" warnings,
  - Mode 6 announces the decision and minimum altitudes. The GPWS includes other functional modes which are not described here since they were not active during the event.

For the purposes of certification in France, several special conditions were applied. The airworthiness sheet N°IM 154 of November 1989 relative to the DC9-83 type Airworthiness Certificate specifies:

> *"French Type: The reference fuselage is n°1343 presented to the DGAC in April 1987 and in accordance with the FAA definition, to which certain modifications have been added:*
> *...*
> *- LOC capture priority versus GS capture in ILS capture*
> *- ILS information crossover ADI/HSI*
> *- Altitude vocal warning at 250 ft*
> *- Autopilot disengage aural warning..."*

1.7 Meteorological Information

1.7.1 General Situation

A high altitude ridge was situated over France, between two disturbances: one situated over the Gulf of Genoa and the other arriving over Finistere in the morning. Over the majority of the country, wet air remained locked in at lower levels.

Early morning fog, occasionally very thick, formed over all regions of northwest France and in particular over the "Ile de France" and the "Centre" regions. In the afternoon, low clouds, mist and fog, thick in parts, persisted to the north of the Seine (see appendix 2).

1.7.2 Flight Dossier Supplied to the Crew

The flight dossier supplied to the crew was picked up at 10 h 13 from the Marseille-Marignane meteorological centre by the airline's operations agent. It included:

- a TEMSI EUROC chart (Western Europe) valid for 23 November 1997 at 12 h,
- the wind and temperature charts valid for 23 November 1997 at 12 h for levels 50, 100, 180, 300, 340, and 390,
- the METAR, TAF, TAFOR and SIGMET for airports situated on the route.

There was no SIGMET message for Orly and Roissy airports. The last METAR and TAF for Orly and for Roissy were as follows:

Destination airport LFPO (Orly)

METAR 231000Z 17003KT 0450 R02/0400N R26/0350N R08/0400V0500N R25/0450D R07/0500V0600N FG VV/// 03/03 Q1020 BECMG 0800 BKN002=

TAF 230800Z 230918 16004KT 0600 FG OVC002 BECMG 0911 16006KT 2000 BR SCT008 BKN012 BECMG 1215 5000 SCT015 BKN050 BECMG 1518 8000 SCT015 SCT050 BKN100=

Alternate Airport LFPG (Charles de Gaulle)

METAR 231000Z 14005KT 0250 R27/0250N R09/0250N R28/0350N R10/0350N -DZ FG VV/// 04/04 Q1020 NOSIG=

TAF 230800Z 230918 12005KT 0600 FG VV/// BECMG 0911 2000 BR BKN002 BECMG 1113 6000 NSW BKN008 BECMG 1416 SCT008 BKN015 T06/12Z T08/15Z=

1.7.3 METAR and TAF at 11'o'clock

The crew were not informed of the 11'o'clock TAF and METAR.

Destination airport LFPO (Orly)

METAR 231100Z 17004KT 0300 R02/0250V0350N R26/0250V0400N R08/0250V0400N R25/0300N R07/0350N FG VV/// 04/04 Q1020 NOSIG=

TAF 231100Z 231221 16004KT 0800 FG BKN002 BECMG 1214 16006KT 2000 BR BKN005 BECMG 1417 4000 BR SCT008 BKN012 TEMPO 1517 5000 BKN015=

Alternate airport LFPG (Charles de Gaulle)

METAR 231100Z 14005KT 100V170 0350 R27/0200V0400D R09/0450D R28/0250D R10/0200V0350N –DZ FG VV/// 04/04 Q1020 NOSIG=

TAF 231100Z 231221 12005KT 0500 FG VV/// BECMG 1315 0900 BKN002 TEMPO 1518 1400 BCFG BKN004 BECMG 1820 0500 VV/// T05/15Z T04/18Z

1.7.4 Meteorological Information received in flight

During the approach, the crew received the following meteorological information:

- Orly "Sierra" ATIS at 11h30, which specified:
  - "Low visibility procedure in force on the runways 07 and 08",
  - "Visibility 250 meters",
  - "Fog, lower than 100 feet",
  - "QNH 1020",
  - "Wind 150 degrees, 3 kt".

- Roissy "Oscar" ATIS at 11h30, which specified:
  - "LVP in place",
  - "RVR between 200 and 250 meters",
  - "Fog",
  - "QNH 1019",
  - "Wind 160 degrees, 6 kt".

Orly Approach supplied the following information at 12 h 14 min 43 s: "... radar vectoring ILS zero seven RVR five hundred meters and three hundred twenty-five meters".

Orly Tower supplied the following information at 12 h 29 min 53 s: "... runway zero seven the RVR four hundred, two hundred seventy-five meters and the wind is calm".

1.7.5 Meteorological Conditions at Orly during the Approach

12 h and 12 h 30 METAR:

231200Z 18004KT 150V220 0250 R02/0250V0350N R26/0350N R08/0250V350N R25/0250V0400N R07/0350N FG VV /// 04/04 Q1020 NOSIG=

231230Z 13004KT 100V190 0250 R02/0350N R26/0350V0600U R08/0250V0400N R25/0300V0450N R07/0400N FG VV /// 04/04 Q1020 NOSIG=

Meteorological parameters at 12 h 30 and 12 h 32:

- 12 h 30
  Wind at threshold 07:
  - Average over two minutes: 130 degrees, 2,7 m/s
  - Real speed: 3,3 m/s

  RVR at threshold 07: 375 m; RVR mid runway 07: 275 m
- 12 h 32
  Wind at threshold 07:
  - Average over two minutes: 120 degrees, 2,4 m/s
  - Real speed: 3,3 m/s

  RVR at threshold 07: 350 m; RVR mid runway 07: 300 m

1.7.6 Visibility on Runway 07 at Orly during the Approach

The runway 07 RVR figures are shown in the chart below. The crew's operational minima, overflight time at the Outer Marker and landing time and the times when ATC communicated the RVR figures are also shown.

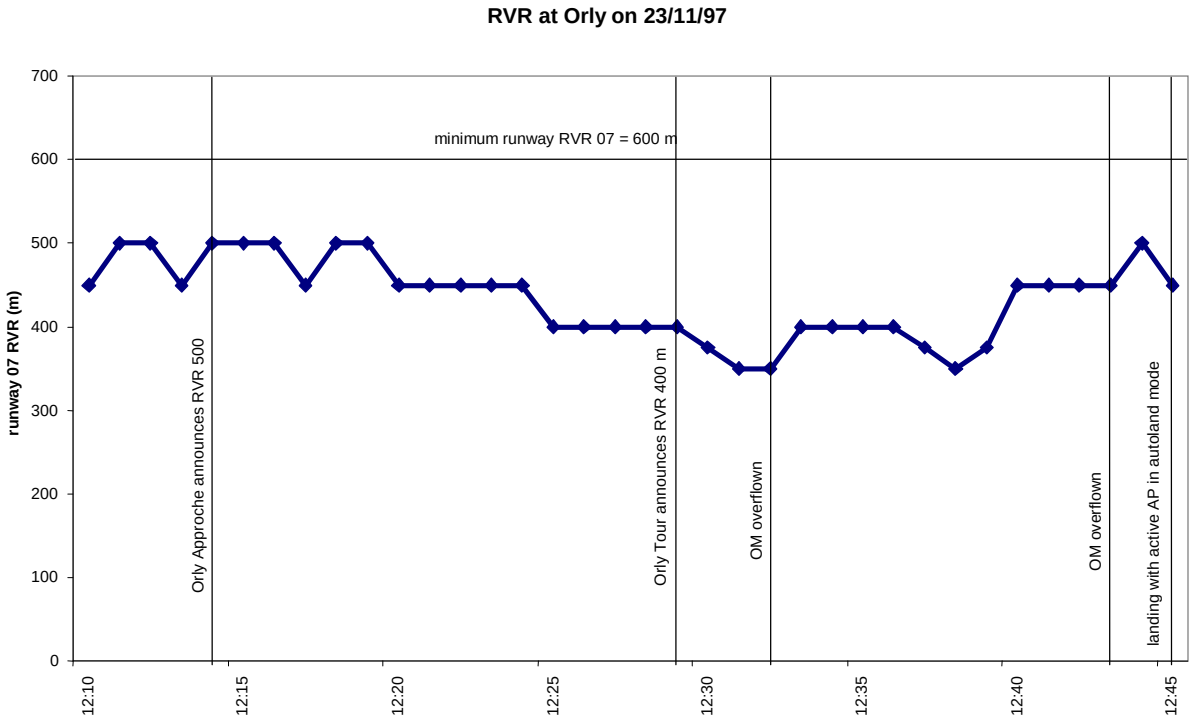


Figure 3

1.7.7 Visibility on Runways 07 and 26 at Orly during the Approach of the Previous Flight

The RVR's recorded at Orly at the time of the morning Toulon-Orly flight are shown in the following chart. The crew's operational minima are also shown.

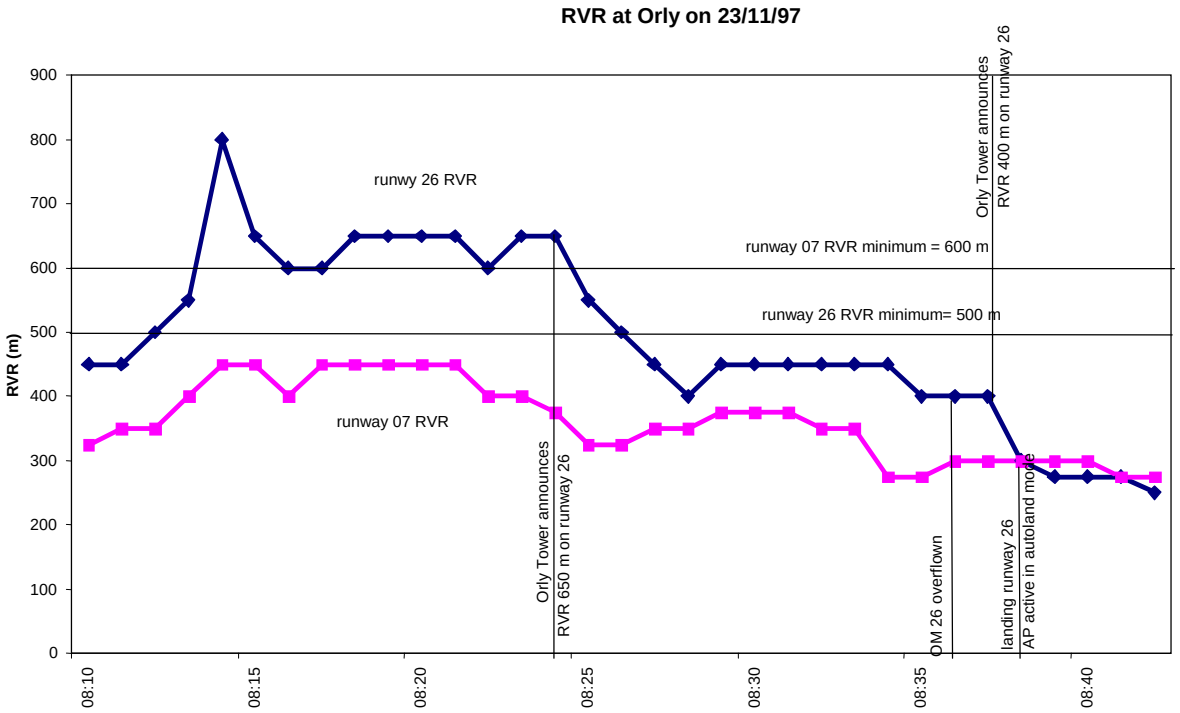


Figure 4

1.8 Aids to Navigation

The approach procedures to runway 07 at Orly depend on the following equipment:

- the Melun "MEL" VOR on the 109.800 MHz (IAF) frequency,
- the Orly "OL" VOR DME on the 111.200 MHz frequency,
- the Orly "ORW" ADF on the 402 kHz frequency,
- the Orly "ORE" runway 07 ILS on the108.500 MHz runway localizer frequency associated with the "OL" DME,
- the Outer Marker and the Middle Marker positioned at 4 and 0,6 NM from threshold 07,
- runway lighting including 720 meters of high intensity centreline approach lighting, unidirectional green high and low intensity threshold lights, runway edge lights and white floodlights, unidirectional flashing lights and ICAO-type high and low intensity runway lighting.

The 07 ILS is class IIIE4, which is the highest level of performance for an ILS and permits category III approaches to be made.

The Orly ATC has the following radar equipment:

- a type TA.10 primary radar operating on the S band (10 cm) connected to a dish turning at a speed of 15 rpm with an effective useful range of 45 NM,
- a type TA.23 primary radar operating on the L band (23 cm) connected to a dish turning at a speed of 15 rpm with an effective useful range of 80 NM,
- the three monopulse radars at Palaiseau, Coubron and Tours which facilitates visualization of the airplane's flight level when it is using an alticoder,
- an ASTRE type surface radar operating on the KU band (2 cm) connected to a dish turning at a speed of 60 rpm with an effective useful range of 5 to 10 NM.

The technical services' and Orly control tower's logbooks for 23 November 1997, along with most recent calibrations show no malfunctions in the systems mentioned above.

1.9 Telecommunications

1.9.1 Recording of Telecommunications

On arrival at Orly, the crew contacts the following organizations successively:

- Paris ATC on 135.300 MHz and 125.700 MHz,
- Orly Approach on 118.850 MHz,
- Orly Tower on 118.700 MHz.

Morning flight (Toulon-Orly):

Transmitting Station	Receiving Station	UTC Time	Communications
AOM 152 BV	Orly Approach	08:08:23	Orly French Line one hundred fifty two Bravo Victor hello
Orly Approach	AOM 152 BV	08:08:31	Euh French Line Bravo Victor hello radar contact maintain level seven zero Melun heading two eight zero then radar vectoring I L S zero seven
AOM 152 BV	Orly Approach	08:08:41	Melun heading two zero one and for I L S zero seven we'll be cat three
Orly Approach	AOM 152 BV	08:08:47	Roger
…			
Orly Approach	AOM 152 BV	08:20:59	French Line one hundred fifty two Bravo Victor right heading thirty cleared for I L S zero seven call back when stabilized
AOM 152 BV	Orly Approach	08:21:04	Heading thirty by the right I L S zero seven we will call back when stabilized French Line Bravo Victor
…			
Orly Tower	AOM 152 BV	08:22:31	French Line Bravo Victor hello call back Outer Marker zero seven two hundred twenty degrees two knots
AOM 152 BV	Orly Tower	08:22:36	Will call you back at Outer Marker zero seven French Line Bravo Victor
Orly Tower	AOM 152 BV	08:23:06	French Line Bravo Victor maintain three thousand feet to Q N H we're going to bring you in on twenty six we have a lighting problem on zero seven ... you are still at three thousand
AOM 152 BV	Orly Tower	08:23:15	we are still stable at three thousand French Line Bravo Victor
Orly Tower	AOM 152 BV	08:23:18	Ok
…			
AOM 152 BV	Orly Tower	08:24:24	French Line One hundred fifty Two Bravo Victor what are your intentions at runway twenty six?
Orly Tower	AOM 152 BV	08:24:29	Okay Bravo Victor it will be twenty six we were just deciding it will be runway twenty six so prepare for twenty six and maintain heading four twenty ten
AOM 152 BV	Orly Tower	08:24:39	Okay for twenty six heading four twenty ten Bravo Victor
Orly Tower	AOM 152 BV	08:24:40	Bravo Victor for info on twenty six one hundred fifty four one hundred fifty and six hundred
AOM 152 BV	Orly Tower	08:24:46	Roger we'll take it
…			
Orly Tower	AOM 152 BV	08:31:52	French Line Bravo Victor keep left on heading three hundred intercept I L S twenty six
AOM 152 BV	Orly Tower	08:31:56	Three hundred by the left for the I L S twenty six Bravo Victor
AOM 152 BV	OrlyTower	08:34:26	French Line One hundred fifty Two Bravo Victor we are stabilized for twenty six

Transmitting Station	Receiving Station	UTC Time	Communications
OrlyTower	AOM 152 BV	08:34:31	Roger Bravo Victor call back when passing the Outer Marker on twenty six wind one hundred four twenty ten degrees three knots
AOM 152 BV	OrlyTower	08:34:36	Call back passing the Outer Marker twenty six French Line Bravo Victor
AOM 152 BV	OrlyTower	08:36:27	French Line Bravo Victor we are passing the Outer Marker on final twenty six
AOM 152 BV	OrlyTower	08:37:28	French Line Bravo Victor on short final twenty six
OrlyTower	AOM 152 BV	08:37:30	Bravo Victor cleared for landing on twenty six two hundred degrees three knots first third four hundred second four one hundred fifty third five hundred call back on the ground or on go-around
AOM 152 BV	OrlyTower	08:37:39	call back on the ground or on go-around Bravo Victor
AOM 152 BV	OrlyTower	08:38:38	French Line Bravo Victor on the runway twenty six
OrlyTower	AOM 152 BV	08:38:41	Roger runway clear

Incident flight (Marseille-Orly):

Transmitting Station	Receiving Station	UTC Time	Communications
AOM 156 BV	Paris ATC	11:52:44	Paris hello French Line one hundred fifty six Bravo Victor level two four twenty.
Paris ATC	AOM 156 BV	11:52:52	French line one hundred fifty six Bravo Victor hello arrival Orly Oscar (cut) Echo RVR runway zero seven four hundred meters are you able to land?
AOM 156 BV	Paris ATC	11:53:05	Affirmative so we need two hundred meters for the zero seven.
Paris ATC	AOM 156BV	11:53:06	Bravo
AOM 068 ZO	Paris ATC	11:53:07	French Line Zulu Oscar behind my colleague level two four twenty.
Paris ATC	AOM 068 ZO	11:53:11	Hello Zulu Oscar arrival also (Autun (?) three Echo for Orly, are you able to land
AOM 068 ZO	Paris ATC	11:53:15	As my colleague, the same.
Paris ATC	AOM 068 ZO AOM 156 BV	11:53:17	Err so okay it's okay for both of you thanks
...			
Orly Approach	AOM 068 ZO	12:14:43	Hello French Line Zulu Oscar radar contact descend to level sixty Melun radial two eight six radar vectoring ILS zero seven RVR five hundred meters and three cent twenty-five meters.
Orly Tower	AOM 068 ZO	12:29:53	Zulu Oscar hello one hundred sixty knots call back at Outer Marker runway zero seven the RVR four hundred, two hundred seventy-five meters and the wind is calm.
AOM 068 ZO	Orly Tower	12:30:02	Roger we intercept the ILS zero seven French Line Zulu Oscar.
Orly Tower	AOM 068 ZO	12:30:53	err French line Zulu Oscar ?

Transmitting Station	Receiving Station	UTC Time	Communications
AOM 068 ZO	Orly Tower	12:30:55	Yes I'm listening.
Orly Tower	AOM 068 ZO	12:30:56	Yes you are about a mile and a half north of the track there you're going over the marker
AOM 068 ZO	Orly Tower	12:31:02	Yes we're coming back onto the track there Zulu Oscar.
Orly Tower	AOM 068 ZO	12:32:13	Zulu Oscar are you stabilized?
AOM 068 ZO	Orly Tower	12:32:15	Negative we are going around French Line Zulu Oscar.
...			
Orly Tower	AOM 068 ZO	12:34:50	Zulu Oscar did you have problems with the ILS?
AOM 068 ZO	Orly Tower	12:34:54	No we were not stabilized we went around we couldn't intercept the glide path
Orly Tower	AOM 068 ZO	12:34:59	Because I saw you very low.

N.B: A complete transcript of telecommunications for the incident flight can be found in appendix 3.

1.9.2 Radar Recording

The CRNA North supplied the recording of the radar images. This recording made it possible to reconstitute:

- the airplane's ground track,

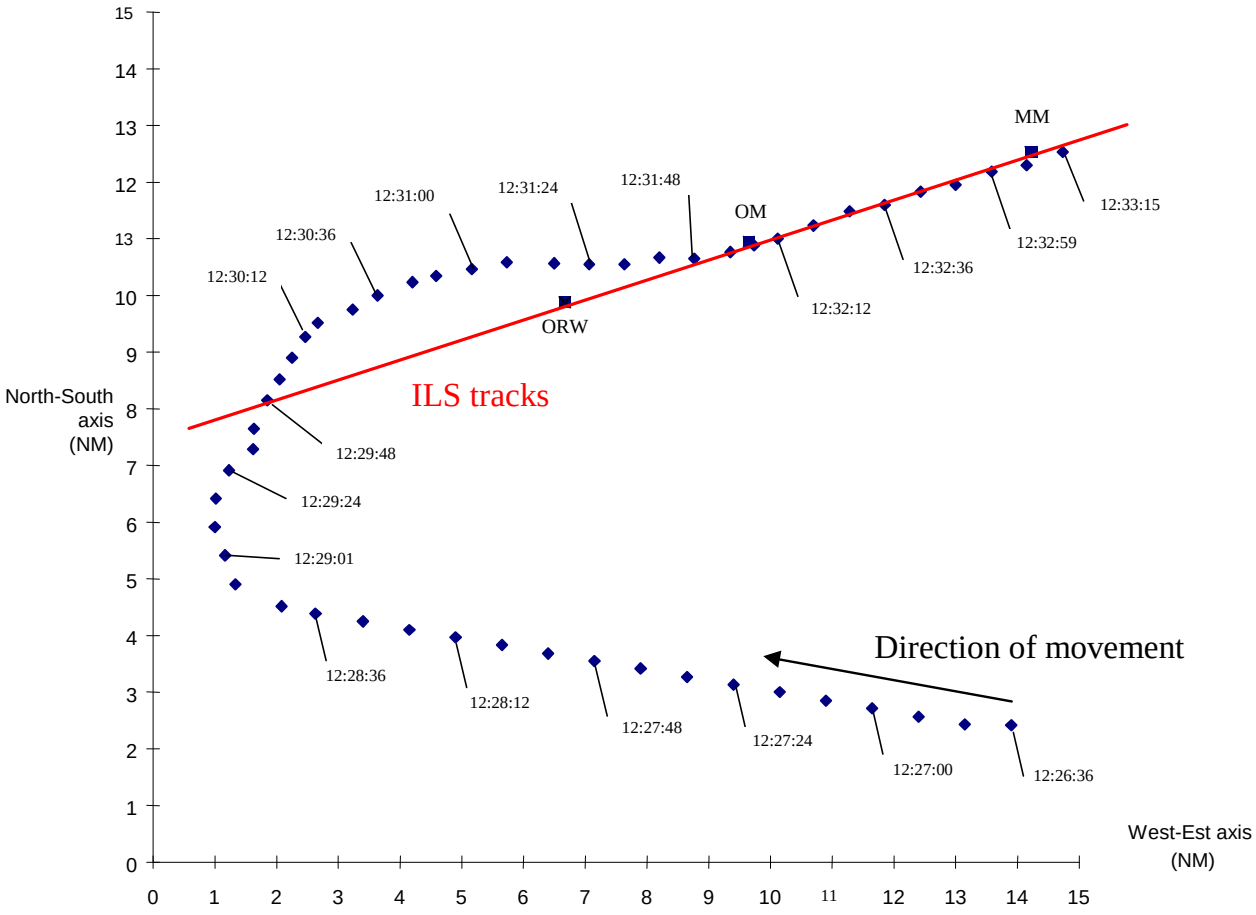

North-South axis (NM)
West-Est axis (NM)
ILS tracks
Direction of movement
MM
OM
ORW
12:33:15
12:32:59
12:32:36
12:32:12
12:31:48
12:31:24
12:31:00
12:30:36
12:30:12
12:29:48
12:29:24
12:29:01
12:28:36
12:28:12
12:27:48
12:27:24
12:27:00
12:26:36

Figure 5

- and the airplane's vertical track thanks to the alticoder on board:

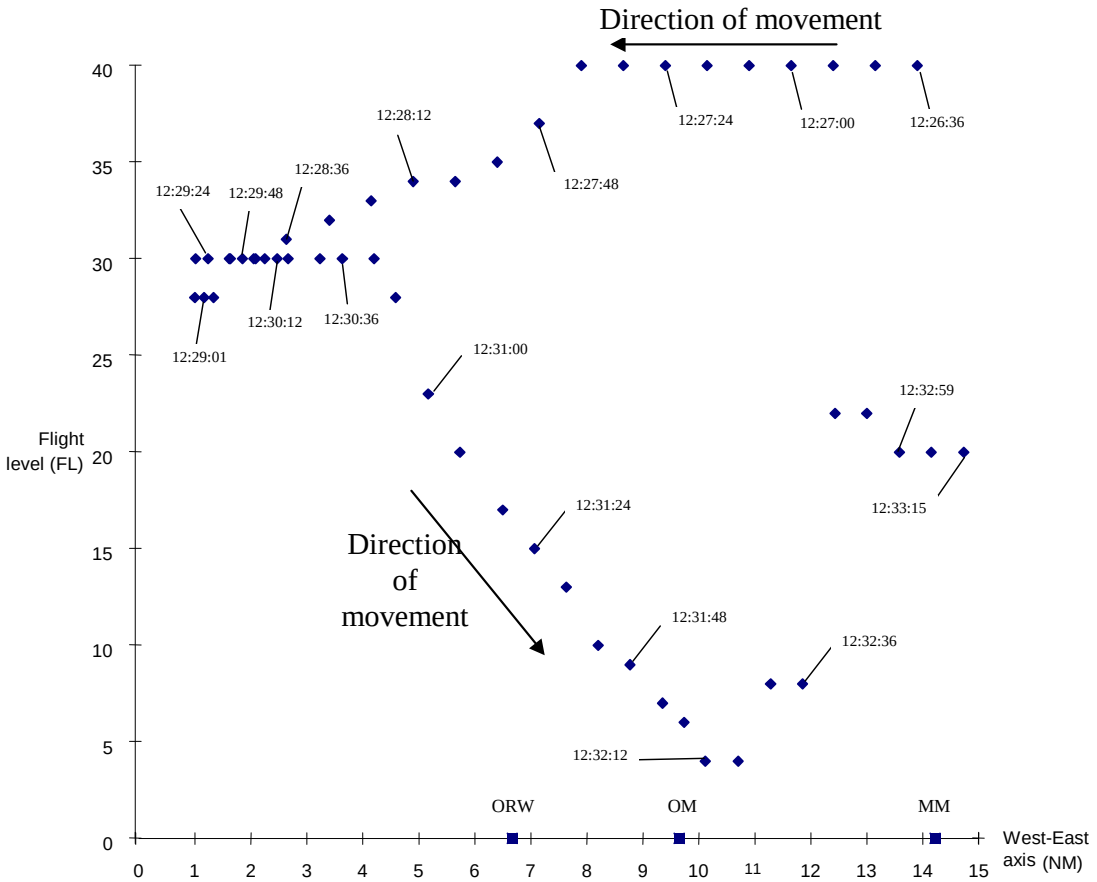


Figure 6

1.10 Aerodrome Information

Orly Airport is a controlled civil aerodrome open to public air transport traffic and operated by Aéroports de Paris (ADP). The aerodrome's reference altitude is 292 feet and the altitude at the threshold of runway 07 is 289 feet.

On the day of the incident, the aerodrome was operating under Low Visibility Procedure (LVP) conditions. In this situation, the Orly Operating Manual specifies that, in "East" configuration, runway 07 is to be used for landings and runway 08 for takeoffs, and that simultaneous takeoffs and landings cannot take place (the runways are linked).

Published runway 07 ILS arrival procedure at Orly (see instrument approach charts in appendix 4)

The approach begins vertically above the MEL VOR, at flight level 60 and on a 286° route. The track descends towards 4,000 feet QNH. On bearing 209° of the OL VOR DME, 22 NM further, the track descends towards 3,000 feet QNH. After 6,4 NM, on a bearing 227° from OL, the track turns right towards a 335°route. On bearing 239° from OL, the airplane track must be stabilized at à 3,000 feet QNH and turn right to intercept the 065° track of the 07 ILS.

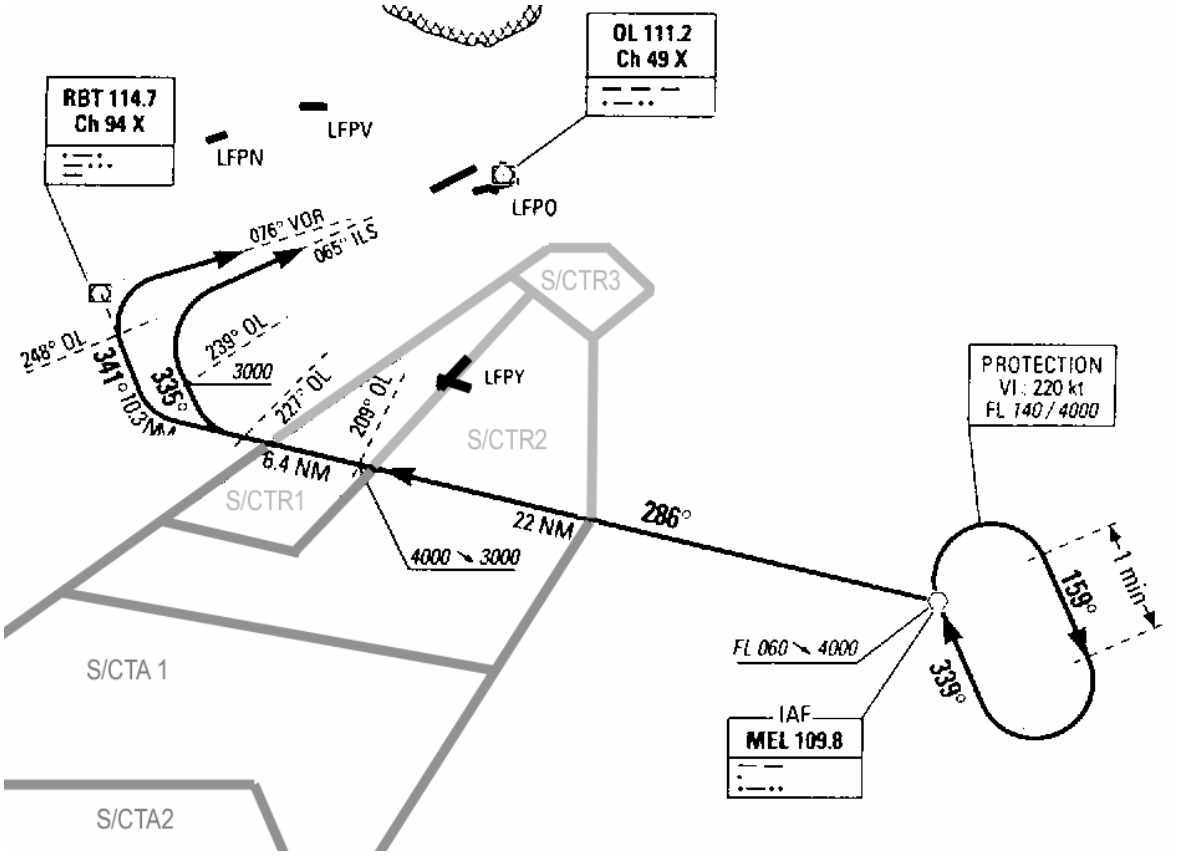


Figure 7: Extract from the IAC chart

The final approach start point is at 11 NM from OL. From this point onwards, the track follows a slope of 5,2%. Above the ORW ADF located 8,8 NM from OL, the airplane must be at an altitude of 2 330 feet QNH. Over the OM located at 6,6 NM from OL, the airplane must be at an altitude of 1 620 feet QNH. Finally, when the airplane is at decision height (200 feet under reduced category I), the crew must abort the landing if they have no visual references.

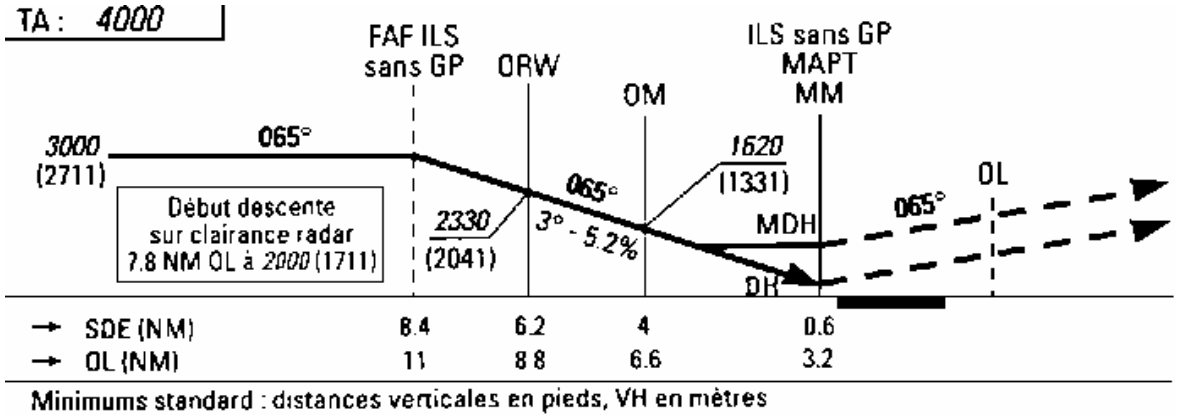


Figure 8: Extract from the IAC chart

1.11 Flight Recorders

The airplane was equipped with three recorders*:*

- a Cockpit Voice Recorder (CVR) manufactured by Sundstrand (P/N 980-6005-076 and S/N 10188),
- a Flight Data Recorder (FDR) manufactured by Sundstrand (P/N 980-4100-DXUS and S/N 10392),
- an Optical Quick Access Recorder (O.QAR) manufactured by Teledyne (P/N 2248000-41 and S/N 272).

The BEA was informed of the incident four days after its occurrence. The airplane had then flown for a further forty hours when the recorders were removed. The CVR had recorded the last thirty minutes of flight and the FDR the last twenty-five hours of flight. They thus contained no information about the event.

Before the BEA was informed of the incident, the QAR had been read out by Alyzair, which handled flight analysis for the operator. It contained information relevant to the incident. This information was subsequently analyzed by the BEA.

A chronological presentation appears in appendix 5. It begins at 12 h 21 min 09 s. It includes the significant parameters and all of the changes in modes displayed on the FMA from 3,500 feet before the descent until the stabilization after the go-around. FMA modes are recorded only every four seconds. One or more mode changes can thus occur during this time period.

The following facts are of note:

- at 12 h 28, the airplane was stable on heading 286° with a rate of descent calculated from altitude vales of the order of 550 feet/min;

- between 12 h 28 min 27 s (pressure altitude: 3 173 feet, reference 1 013 hPa) and 12 h 32 min 09 s (radio-height*:* 67 feet), the modes displayed on the FMA changed 30 times;

- from 12 h 28 min 27 s, the airplane turned right to rejoin the approach track;

- at 12 h 29 min 47 s the airplane crossed the approach track from the right towards the left then the heading increased in successive steps;

- at 12 h 30 min 20 s the airplane moved above the descent path; at 12 h 30 min 43 s the airplane descended in "Vertical Speed" mode at a speed of 2 300 feet/min (speed calculated from altitude values); at 12 h 31 min 06 s the airplane went below the descent path with a radio altimeter height of 1,502 feet;

- at 12 h 31 min 26 s the QAR recorded the GPWS "Glideslope" warning followed by the GPWS "Terrain" warning between 12 h 31 min 30 s and 12 h 31 min 32 s;

- between 12 h 31 min 54 s (radio-height*:* 279 feet on descent) and 12 h 32 min

03 s (radio-height: 104 feet climbing), GPWS "Terrain" warning was recorded by the QAR;

- à 12 h 31 min 59 s (radio-height: 164 feet), the horizontal "GO AROUND" mode was displayed on the FMA, indicating that the go-around had begun. The other parameters confirmed this in the following seconds ;

- The lowest radio-height recorded was that at 12 h 32 min 09 s*:* 67 feet. The GPWS warnings also stopped at this time.

Note 1: The "Glideslope", "Terrain", "Master Warning", and "Thrust Reversers Deployed" warnings were recorded on the QAR simultaneously for eight seconds around flight level 180. Evidently, this data was erroneous.

Note 2: The QAR records only the two alarms associated with the GPWS: "Glideslope" and "Terrain".

1.12 Wreckage and Impact Information

Not applicable.

1.13 Medical and Pathological Information

The medical facts collected and examined by the BEA's medical specialist brought to light no evidence of any factors related to the event.

1.14 Fire

Not applicable.

1.15 Survival Aspects

Not applicable.

1.16 Tests and Research

1.16.1 GPWS

The MK VII GPWS on F-GRMC generates visual and aural warnings. The visual warnings are two warning lights in the cockpit: "GPWS" and "Below GS". The "Below GS" warning illuminates when the aural "Glideslope" warning is active. The "GPWS" warning illuminates when the aural "GPWS" warning is activated, except for the "Glideslope", "Minimum" or height announcements. These aural warnings are, for example: "Terrain Terrain", "Pull Up", "Sinkrate", "Don't Sink" (takeoff only), "Too Low - Terrain" (at flap retraction), "Too Low - Flaps", or "Too Low - Gear".

The BEA had the GPWS examined on 22 December 1997 at Allied Signal in Toulouse. The object of the examination was the read out the GPWS BITE memory and to test if it was functioning correctly.

- Two types of warnings appeared during the incident flight, "Glideslope" and "Sinkrate", were recorded. They were not dated. The time and the number of occurrences during the flight were not recorded.

Note: the GPWS did not record any "Terrain" type warnings although the QAR recorded warnings entitled "Terrain" (see 2.13.).

- The non-volatile recording contained no failure recordings and the result of the GPWS test program was correct.

In May 1998 Allied Signal, at the request of the BEA, carried out a simulation of GPWS MK VII warnings using data from the flight. The results of this simulation were as follows:

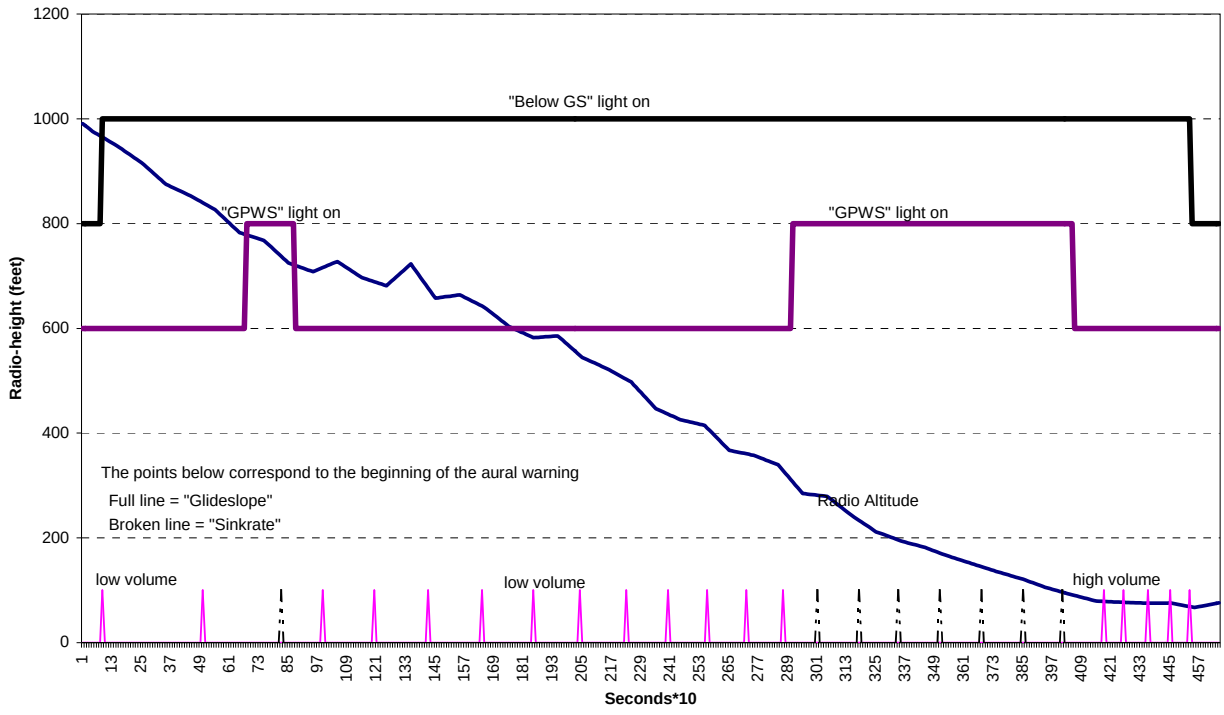


Figure 9

The warnings which appeared are of the "Low Volume Glideslope", "Sinkrate", and "High Volume Glideslope" type. The times when the "Glideslope" and "Warning" lights came on during the simulation correspond to the respective times when the "Glideslope" and "Terrain" warnings were recorded on the QAR.

1.16.2 MSAW Simulations

The Minimum Safe Altitude Warning (MSAW) is a system which, on the basis of

radar data, warns the controller in case the airplane's proximity to the ground is judged too dangerous. At the request of the BEA, the CENA (Centre d'Etude de the Navigation Aérienne) performed a simulation of the MSAW functions based on the Rheims radar recording. Parameters identical to those used at Lyon Satolas were used since this system is not installed at Orly. The vertical speed had to be estimated, since it was not available on the radar recordings.

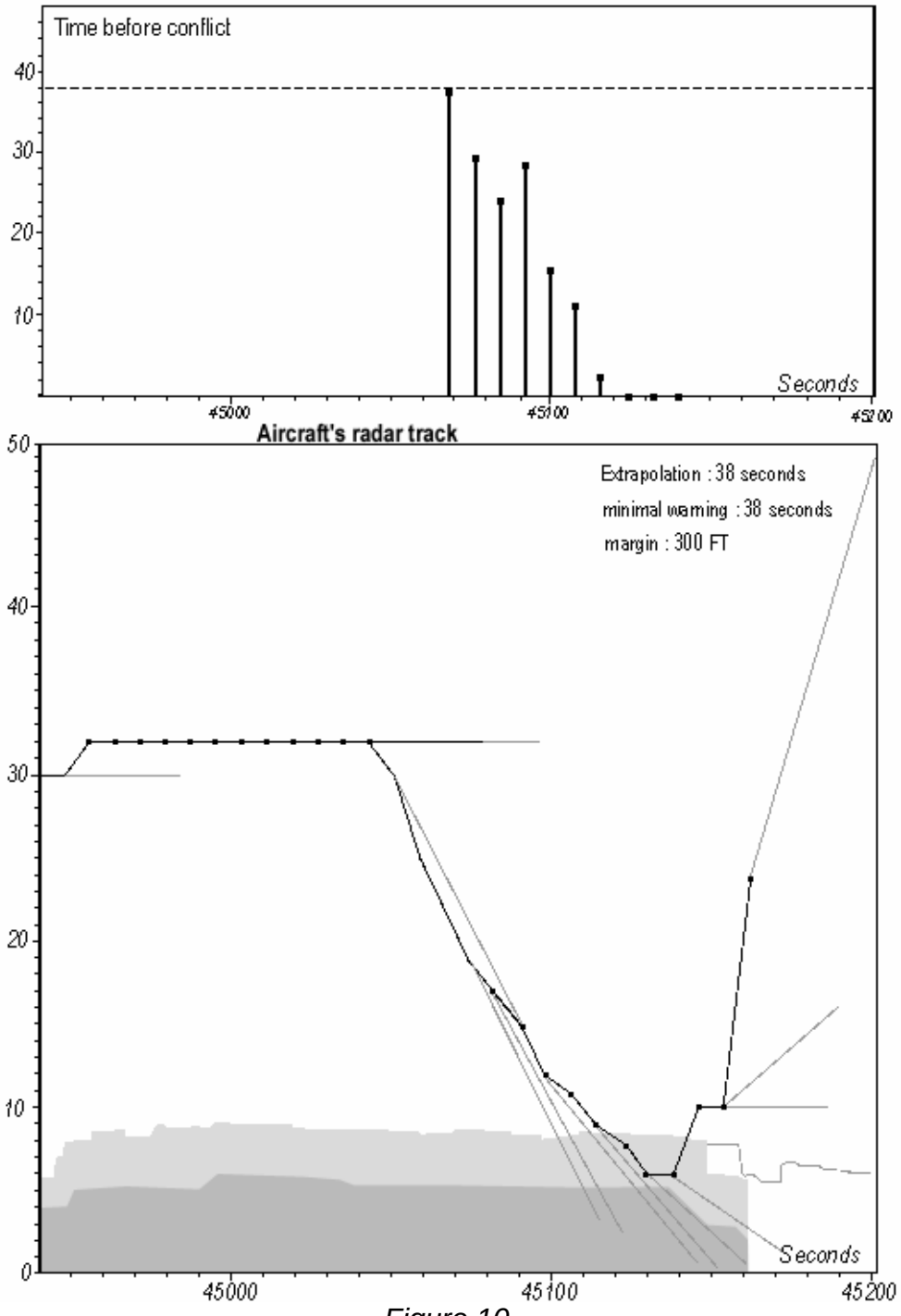


Figure 10

In the simulation report, the CENA concluded: "*Supposing a correct Vz STR (accurate estimate of the vertical speed) the MSAW warning could have been transmitted to the controller at 12 h 31 min 24 s. Allowing time for the controller's*

reaction, the transmission and the pilot's reaction (15 seconds), the pilot could have started the go around at 12 h 31 min 39 s ...".

1.16.3 Simulations on Flight Simulator

On the 6 and 7 May 1998, the BEA organized some tests on the Raytheon MD83 flight simulator at Gatwick, used by AOM Minerve S.A. for training its pilots. The investigators were assisted by three AOM Minerve S.A pilot instructors and two researchers from the Applied Anthropology Laboratory. The test program included six main sequences as well as a reconstruction of the whole event.

During these tests it was noted that, whether the active mode was "heading select" or "localizer capture", the Flight Director remained cantered as long as the autopilot was active or as long as the wrong ILS heading was selected (258°).

SEQUENCE A

Objectives

- Observe the airplane track during interception of the approach track (localizer then glide) on automatic under the conditions at the time of the incident, but while selecting the correct ILS heading (065°).
- Observe the airplane track during interception of the approach track (localizer then glide) on automatic under the conditions at the time of the incident.
- Subsequently, observe the information supplied by the localizer and the glideslope track on the HSI during interception of the ILS.

Results

When the correct ILS heading was selected, the airplane lined up on the approach track then intercepted the glide path in autoland mode.

Under the conditions at the time of the incident, with incorrect selection of the ILS heading, the simulator behaved in the following way:

- the airplane maintained 020° heading throughout the ILS track interception phase
- "LOC HEADING" appeared on the FMA towards two points deviation from the localizer while the speed was about 170kt dropping towards 160 kt
- "G/S HEADING" appeared on the FMA towards 0.25 points deviation from the glideslope track and 4.30 points deviation from the localizer
- "G/S TRK" appeared on the FMA towards 0.03 points deviation from the glideslope track and 4.58 points (maximum value) deviation from the localizer.
- the auto-pilot disconnected without any action from the crew at the same time as loss of the glideslope signal. Subsequently the FMA continued to display "LOC CAP" and "G/S TRK".

The FMA indicators, "LOC CAP", "G/S CAP" and "G/S/ TRK" were green since they are not armed modes but active modes. Display of "LOC CAP" and "G/S CAP" indicates that the capture modes are active and that the localizer and glideslope beams are going to be captured.

In conclusion, the airplane did not line up on the approach track. It maintained its 020° intercept heading then intercepted the descent path.

SEQUENCE B

Objective

- Study whether Altitude mode arming is maintained in case of action on the vertical speed wheel.

Results

Having as initial conditions the "ALT" mode armed with a selected vertical speed and altitude:

- when the vertical speed wheel was activated while the "ALT" mode was displayed on the FMA, this mode was not disarmed and the airplane searched for the selected altitude.
- when the vertical speed wheel was activated while the "ALT HEADING" mode or the "ALT HLD" mode were displayed on the FMA, these modes were de-activated and the airplane continued on its track with the new vertical speed displayed.
- without any action on the wheel, the vertical speed of the airplane was modified significantly as soon as the "ALT HEADING" mode appeared on the FMA.

The tests also allowed observation of the alarms associated with the altimeter. When the airplane was descending from 3,000 towards 2,000 feet QNH, with a selected but not armed altitude of 2,000 feet, auto-pilot and "VERT SPD" mode active, the following was noted:

- at 2,750 feet, a bell and the illumination of the altimeter light for a few seconds,
- at 1,750 feet, a bell, the illumination of the altimeter light and an intermittent "ALTITUDE" announcement until the pilot cancelled the alarm,
- at 1,250 feet, a bell, the illumination of the altimeter light and an intermittent "ALTITUDE" announcement until the pilot cancelled the alarm.

SEQUENCE C

Objective

- Observe FMA mode changes on a manual go-around under the incident flight conditions then under stabilized approach conditions.

Result

The simulation could not re-create the appearance of the "EPR MCT" and "ALT HLD" modes on the FMA as recorded by the QAR during the go-around.

Note: the appearance of these modes could not be explained by the airplane manufacturer (see 1.18.5.3).

SEQUENCE D

Objectives

- Identify the priorities for visual and aural information associated with the GPWS, the autopilot, the altitude and passing over the Outer Marker.
- Observe if the autothrottle disconnects.
- Observe the speed modes displayed on the FMA.

The simulation sequence reproduced the final approach followed by a go-around under the conditions of the incident flight.

Results

The reproduction of the GPWS warnings was not exactly that which appeared during the GPWS simulation carried out by Allied. For example, the "High Volume Glideslope" warnings were not reproduced during the simulation. This is explained by the representation of terrain contours in the MD83 simulator and by the difficulty in reproducing the descent rate exactly. However, the results of the test on the simulator were consistent with those of Allied Signal.

SEQUENCE E

Objective

- Reproduce the appearance of mode sequences on the FMA under the conditions of the incident flight by selecting the "Heading Select" mode several times.

Result

Selecting heading select resulted in disarming all the automatic modes. The Flight Director remained active.

SEQUENCE F

Objective

- Reproduce the appearance of mode sequences on the FMA under the conditions of the incident flight by connecting and disconnecting the autopilot several times.

Result

Disconnection of the auto-pilot resulted in reversion of the armed "Autoland" mode to "ILS" mode, but had no effect on the armed "ILS" mode.

1.16.4 Calculation of the FO's Flying Hours during LOFT

The FO's flying hours were estimated by two methods based on the flying hours listed in the AR tables shown in appendix 1.

The first method was to count the flying hours when a FO made a landing. To this was added the flights for which it was not possible to determine whether he performed the landing. The second method was to count the flying hours only when it was sure that the FO performed the landing.

a) co-pilot's flying hours

- according to the AR: 25 hours 9 minutes for 14 landings
- first method: 18 hours 59 minutes for 14 landings
- second method: 16 hours 6 minutes for 12 landings

The AR indicates that this FO on LOFT performed at least four flights, or 6 hours 10 minutes more than the real figure. This error represents 25% of his flying time.

b) flying hours for the FO on LOFT in the observer's seat

- according to the AR: 27 hours 9 minutes for 12 landings
- first method: 19 hours 44 minutes for 12 landings
- second method: 15 hours 30 minutes for 11 landings

The AR indicates that this FO on LOFT performed at least five flights, or 6 hours 25 minutes more than the real figure. This error represents 26% of his flying time.

1.16.5 Fatigue, Workload and Ergonomics

The Applied Anthropology Laboratory (LAA) contributed to the investigation in the fields of fatigue, workload and ergonomics. The researchers used evidence possessed by the BEA, met with the Captain and the FO on LOFT in the observer seat and participated in some of the flight simulator tests. The document entitled "contribution to the analysis of the incident on 23 November 1997" is in appendix 6.

1.16.5.1 Crew Fatigue

Analysis of the activity-rest cycles shows that, at the time of the flight, the Captain had a high level of fatigue linked to:

- the extent of his duty time,
- the nature of the flights undertaken as an instructor.

The two FO's showed a moderate level of fatigue.

1.16.5.2 Captain's Workload at the time of the Incident

The LAA concluded that during the final approach, the Captain handled the very high workload alone, due to the circumstances of the event. It was difficult to manage due to his fatigue and the absence of input from the co-pilot.

The tests performed on the simulator confirmed the extent of this workload, added to by numerous simultaneous alarms, with some critical factors from the point of view of sensory ergonomics.

1.16.5.3 Airplane Ergonomics

The LAA estimated that elements related to cockpit ergonomics could have contributed to the incident. These include: the presence of incorrect information on the FMA; difficulty in detecting a selection error on the HSI[2] and the presence of simultaneous aural alarms, presented in such a way as to render them difficult for the crew to detect and handle correctly.

2 The pilot can determine the selected ILS axis in the cockpit by:
- reading the numerical value of the axis on the DFGS
- checking the position of the arrow on the HSI

1.17 Information on Organizations

1.17.1 AOM Minerve S.A.

1.17.1.1 Structure

AOM Minerve S.A., which was created from the merger of Air Outremer and Minerve on January 1 1992, mainly operates scheduled long and medium haul routes. The long-haul route network is served by thirteen DC 10-30s and medium-haul by eleven MD83's.

At the time of the incident, AOM Minerve S.A. employed 2,700 staff, including 280 flight crew and 800 to 1,000 cabin crew.

At the end of 1996, the airline had changed management and significant organisational changes had occurred.

1.17.1.2 Recruitment

The arrival of an extra airplane in April 1997 allowed significant growth in the MD83 sector. Since, in the winter of 1996-1997, it had been decided that there would be no recruitment, there was a shortage of flight crew for the winter of 1997-1998. There were ten pilot instructors in the MD83 sector for forty-four captains and forty-two first officers. Around six months before the incident, the airline had thus decided to train twenty-two FO's, six Captains and undertake two first JAR 25 qualifications. The first wave of training, which included the two co-pilots on LOFT, had begun in October 1997.

1.17.1.3 Training

AOM Minerve S.A. undertakes type rating of its crews for the MD83 itself. The AOM Minerve S.A. MD83 type rating was defined in 1997 (approval 7.18.90 by the SFACT on 16 September 1997).

According to the type rating training program, the training of pilots is carried out in the following way:

- 47 h 30 of airplane theory courses
- 31 h of technical operations courses
- 10 h as PF and 10 h as PNF on fixed-base flight simulator
- 14 h as PF and 14 h as PNF on mobile-base flight simulator
- training checks, 2 h as PF and 2 h as PNF on mobile-base flight simulator
- 1 h 40 of non-line flights
- 12 h of CRM instruction

According to their progress logs, the co-pilot and the FO in the observer seat had followed this course. The CRM training had not been logged, but the operator indicated that it had taken place on 11 November 1998.

At the end of this course, co-pilots undertake line oriented flight training within the airline. This line orientation is performed on the network and includes twenty steps. It is planned that the first six flights be carried out in the presence of an experienced co-pilot who acts as an extra crew member. Later, this second co-pilot is dispensed with when the instructor considers it to be possible. The progress log for the FO in the observer seat showed that he had only performed his first line orientation flight in the presence of a backup pilot.

In March 1994, the airline leased an MD82[3] equipped with "glass cockpit" type instrumentation, that is to say equipped with EFIS. At that time the fleet's MD83 had electro-mechanical instrumentation. A supplementary training course allowing pilots to switch over to glass cockpit airplane was then set up. This meant adding four hours of courses to the theoretical course and ensuring that, for the practical part of the course, each first flight was performed under the effective supervision of an instructor. The DAC Nord stated that this supplementary training applied to experienced pilots.

Progressively, all the MD83's were equipped with cathode ray instruments and the pilots recruited by the airline were trained on MD83's using the 1989 Minerve type rating program (approval n°33549 by SFACT on 30 March 1989, completed by the glass cockpit training, without the latter being modified.

For the practical training, the DAC Nord stated that a verbal agreement had been made with the airline: when the flight simulator training took place on a glass cockpit airplane, the non-line flights were performed on an airplane with electro-mechanical instrumentation. The types of flights undertaken according to the type of instrumentation are identified in appendix 1.

The MD83 sector was the access point into the airline for pilots. After a period on MD83 they could move on to DC10s.

1.17.2 The DAC Nord

1.17.2.1 Organisation of Oversight

The DAC Nord ensures that air transport companies attached to its territory respect safety rules during operation of their airplane. At the time of the event, this role was undertaken by the Air Transport division, which had nine engineers for oversight and four technical operations inspectors.

Oversight of AOM was mainly undertaken by the head of the Air Transport division. He was in frequent contact with the various sections of the airline.

3 The MD 82 is very similar to the MD83, and they the same type rating applies.

1.17.2.2 Most Recent Inspections

An operational inspection carried out by the DAC and the GSAC in January 1997 led to a decision to place the company under closer supervision regarding its maintenance operations. In practice, this meant more frequent inspections by the DSAV (see appendix 7).

In the course of 1997, three satisfactory in-flight inspections were carried out by the Flight Test Centre, two for the DC10 sector an one for the MD83 sector (see appendix 8).

1.17.2.3 Penalties

In case of irregularities, the oversight authority has the power to reinforce its inspections. Some have a financial impact on the operator. There are also three other types of penalties at various levels: the authority can penalize a pilot through the R register; it can withdraw an airplane's air transport certificate for reasons linked only to that airplane; it can suspend or even withdraw the certificate (see appendix 9). These actions, as well as some more stringent inspections, have a financial impact on the operator. Notification of an offence and forwarding the case to the state prosecutor's office can lead to judicial proceedings. The authority responsible for oversight then has the opportunity to arrange a settlement.

1.18 Supplementary Information

1.18.1 AOM Minerve S.A.

1.18.1.1 Management of MD83 Flight Crew

The "General – Lines" volume of the AOM Minerve S.A Operations Manual includes chapters on crew working hours, on instruction (in particular MD83 type rating, approval of Minerve n°33549 SFACT/FP of 30/03/1989) on maintaining, upgrading and checking skills.

Work time for flight crew on jet airplane is defined in D 422-4 (previously D 422-10) of the Civil Aviation Code:

> *"… work time which, expressed as flying hours, must not exceed an average monthly total of 75 per year, the flying hours performed in any single month not exceeding 95 hours, those in two consecutive calendar months 180 hours, nor those in three consecutive calendar months 265 hours …. The monthly limitation of 95 hours must be respected both between the first and last days of each calendar month and between the 16th of one calendar month and the 15th of the following month …".*

1.18.1.2 Precision Approach Procedures

The AOM Minerve S.A Operations Manual contains, in the section on Use, the developed procedures, briefings, task-sharing and check-lists related to precision approaches in reduced category I, categories II and III and to landings. This is registered with the oversight authority.

The Operations Manual contains the following information:

- MD83's are classified in category C, on condition that the MLW is limited to 148,000 lbs flaps 40° and 140,000 lbs flaps 28°,
- *"any approach procedure may be undertaken, whatever the prevailing meteorological conditions at the aerodrome may be, up to a specified point defined as follows: ILS approach: the OM or its published equivalent (in case of failure) … ",*
- *"at the specified point, the approach shall be aborted if the meteorological conditions transmitted by the authorized organisation and received by the crew are lower than the crew's operational minima … Beyond this specified point, whatever the prevailing meteorological conditions may be, the approach may be continued up to DA or to Mapt in case of an MDA…",*
- for category I precision approaches, when several RVR are available, only the value measured at the threshold de runway is to be taken into account,
- *"for French aerodromes only, the REDUCED operational minima are featured in the ILS part of the section called "AUTHORISED OPERATORS". Then, if a numerical note indicates that different values are authorized (France auth) it is these values that are taken into account…. The values in parentheses are only usable by certain authorized Cat II or Cat III operators. They cannot be used by AOM-MINERVE crews.",*
- Jeppesen charts are used by the airline's crews.

Note that the charts (IAC, TMA) contained in the AIP are official, whereas the Jeppesen charts, though widely used, are not.

Application of the above rules for reduced category I approaches to Paris Orly results in RVR minima, for a crew rated as reduced category I, which are 500 m for runway 26 and 600 m for runway 07

Note: Precision approach procedures are currently being studied in the context of the JAA.

1.18.1.3 Minima for the Preparation of IFR Public Transport Flights

Appendix I of the 27 June 1996 Regulations defines the calculation and use of operational minima.

In chapter 7.2, "minima for the preparation of IFR public transport flights", "minima for the destination and alternate destination aerodromes", it is stated that:

> *"For a public transport flight an operator can only select a destination aerodrome and/or an alternate destination aerodrome if the meteorological observations or forecasts or any combination of the two indicate that, for the*

period beginning one hour before and ending one hour after the estimated time of arrival, the meteorological conditions are equal or superior to the minima applicable for the preparation of a flight, defined as follows:

1) flight preparation minima for a destination aerodrome:
i) RVR/visibility specified in accordance with operational minima mentioned in this appendix;
ii) and, for classic approaches or visual manoeuvres, the ceiling is equal or superior to the MDH;

2) and flight preparation minima for the alternate destination aerodrome(s):
Flight preparation minima.
En route and destination alternates.

Type of approach	Flight preparation minima
Categories II and III	Category I (RVR)
Category I	Classic approach Minima (RVR and the ceiling must be equal or superior to the MDH)
Visual Approach	Classic approach (RVR and the ceiling must be equal or superior to the MDH) increased by 200 feet/1,000 m
Visual manoeuvres	Visual manoeuvres

In chapter 7.3, "minima for the preparation of IFR public transport flights", "minima for the destination and an alternate en route aerodrome", it is stated that:

"For a public transport flight, an operator may select an en route alternate aerodrome only if the meteorological observations or forecasts or any combination of the two indicate that, for the period beginning one hour before and ending one hour after the estimated time of arrival, the meteorological conditions are equal or superior to the minima applicable for the preparation of a flight, in accordance with the preceding table".

1.18.2 Air Traffic Operations at Orly

The French Air Traffic Regulations define the services to be provided by Approach and Airport controllers.

In the section on "General Organisation", chapter 2.2.2.3.1 "Responsibility of air traffic organizations relative to air traffic control", "IFR flights", "Collisions with obstacles", it is stated that:

"it is not one of the objectives of air traffic control, outside of the manoeuvring area, to prevent collisions between airplane in IFR flight and obstacles. It is the responsibility of the Captain to ensure that clearances issued by the air traffic control organisation do not compromise safety in this respect, except where the airplane is radar vectored".

In the "Approach control" section, chapter 4.3.7.1 "Arrival information supplied by approach control, it is stated that:

"As soon as possible after establishment of communications between the

airplane and the organization ensuring approach control, the following information will be transmitted to the airplane: …. Latest meteorological conditions… visibility, with any significant variations in direction or, if the information is available, runway visual range". *Then in chapters 4.3.7.2 and 4.3.7.3, it is stated that*: "At the beginning of the final approach the following information shall be transmitted to the airplane … visibility, with any significant variations in direction or, if the information is available, runway visual range" *and that* "During the final approach, the following information shall be transmitted to the airplane … variation in visibility or, if the information is available, runway visual range

In the "Messages from ATC services", chapter 9.3.3.2.4.3 "Messages containing meteorological information", "Specifications of different information transmitted relatives", "Runway visual range", it is stated that:

> "Runway visual range values up to 800 m are given in 25 m to 60 m sections, based on observations available, and values superior to 800 m are given in 100 m sections".

The French Air Traffic Regulations contain the following definitions:

- radar surveillance: "use of radar to determine the position of airplane"
- radar assistance: "use of radar to supply information to airplane on their position or on deviations in relation to their route",
- radar vectoring: "use of radar to supply airplane with specified headings which allow them to follow the desired track".

The Orly Operations Manual defines the functions and responsibilities of LOC controllers as well as the steps to take in case of a precision approach in low visibility. The LOC controller participates in air traffic control for airplane operating on the runways and around the aerodrome.

In chapter 7.3, entitled "Instructions for local controller", the Orly operations manual specifies: *during category II and III approaches:*

- *on first contact, communicate threshold, mid-runway and runway end RVR's ;*
- *at the OM, transmit the new RVR's if the situation has worsened.*

Note: the controller can thus use the radar for radar surveillance, radar assistance and, above the minimum safety radar height, radar vectoring. This height is 2,000 feet QNH around Orly Airport.

1.18.3 Météo-France

Instruction DGO/CO/AERO/96/01 of 2 April 1996 states that:

> *"meteorological observations must be performed in accordance with the recommendations in ICAO annex 3 (supplement B) and the WMO technical regulations, volume II, chapter C.3".*

Regulation DGO/CO/AERO/96/02 of 2 April 1996 states that Paris Orly Airport is in

category one for meteorology, which implies permanent observation with SPECI surveillance undertaken during the period necessary to satisfy the needs of all commercial flights.

Regulation DGO/RE/95/10 of 28 November 1995 defines the criteria for transmitting a trend-type landing forecasts with METAR, the SPECI calculation levels, criteria for insertion of change indicators or to amend the TAF (see appendix 10).

1.18.4 Witness Statements

1.18.4.1 Summary of Crew Members' Statements

The following information comes from documents supplied by the crew, completed by various interviews.

The work period including the incident flight included six legs and a stopover at Toulon. Throughout these legs, the crew consisted of the Captain Instructor and the two FO's on LOFT, who will be referred to as FO on LOFT A and FO on LOFT B to differentiate them. According to the crew, the flights were conducted in the following manner:

DATE	LEG	FO on LOFT
Saturday 22 November 1997	ORLY NICE	A
	NICE ORLY	A
	ORLY TOULON	B
Sunday 23 November 1997	TOULON ORLY	B
	ORLY MARSEILLE	B
	MARSEILLE ORLY	A

The atmosphere in the cockpit was good and calm.

The FO's on LOFT stated that they had never flown together previously. The Captain was in the left seat, the co-pilot in the right seat. According to the crew, the FO on LOFT in the observer seat participated in certain tasks which did not interfere with the conduct of the flight. The FO on LOFT B stated that when seated in the observer seat, she could only see the left altimeter and the right airspeed indicator.

The Captain stated that he had a lot of work because there were a lot of subjects to cover with the FO's on LOFT. During the last flight, subjects covered included fuel and pressurization. The Captain specified that, because of the training, the FO's on LOFT had a heavy workload but that they kept up well with the work rate.

Toulon-Orly Flight on Sunday 23 November 1997

The crew stated:

- that they loaded 21,000 lbs of fuel to cover a diversion to the south of France,
- that during cruise it was decided to undertake a reduced category I approach in

"autoland" mode,

- that the preparation of the approach was detailed: briefing, revision of callouts and check-lists,
- that the runway in service at Orly was runway 07 and that at the time of approach track interception, the controller proposed runway 26 for reasons of lighting,
- that the landing took place in "autoland" mode with the reduced category I minima on runway 26,
- that acquisition of visual references occurred at around 200 feet.

Marseille-Orly Flight on Sunday 23 November 1997

- **Flight preparation in Marseille**

The crew stated that the alternate airport was Paris-Charles de Gaulle. They did not file a flight plan or an amendment to the automatic flight plan. There were no NOTAM's for this flight. The co-pilot studied the meteorological file. The decision to depart was taken on the basis of the Orly TAF. The meteorological conditions forecast for the alternate airport were not examined by the co-pilot but were examined by the Captain. The latter decided to take extra fuel to cover holding at Orly and a diversion to the south of France. No option on the landing direction was chosen during the briefing for arrival at Orly.

- **Takeoff, cruise and approach**

The crew used the Jeppesen charts of 6 June 1997 N°11-2 and 11-2A relating to the runway 07 ILS approach procedure at Paris Orly. The co-pilot was pilot flying from takeoff until the descent checklist at Orly. From this time on the Captain became the pilot flying and the co-pilot handled the radio. Orly Approach gave RVR values for runway 07 which fluctuated a lot and were slightly inferior to the minima for reduced category I. The Captain decided to begin the approach to runway 07 in reduced category I. The check-list and the precision approach briefing were performed. The airplane was radar controlled for runway 07. The co-pilot had selected the OL VOR with track 065. The ORW 402 ADF was selected on head 1 and 2. The Captain stated that he had selected the ARC mode on the ND.

- **The Event**

According to the Captain, he had selected the 108.5 MHz ILS frequency on the VHS NAV 1 panel, announced it and selected the 258° approach track by mistake instead of 065°. The co-pilot stated that he did not check the Captain's selection.

The Captain stated that he armed the "autoland" mode. According to the crew, the co-pilot called out the airplane passing onto the OL 065° track. The Captain saw the "LOC capture" mode appear on the FMA and called out "LOC capture heading QFU". He stated that while looking at the HSI, he set the heading indicator on the ILS bar and noticed an inconsistency. The heading indicate 078° whereas it should have shown the runway 07 QFU, that is to say 065°.

The Captain stated that he selected the "heading" mode without calling it out. He requested landing gear extension. When the airplane was at an altitude of 3,000 feet QNH and had not begun the descent, the Captain noticed that the airplane had gone above the glideslope track and was not on the localizer track. He armed the "autoland" mode then selected an altitude off 2,000 feet, "vertical speed" mode at 1,500 feet per minute and the "heading" mode on heading 090°.

According to the crew, the beginning of the descent was performed in VMC. The Captain asked for flaps extension to 28. The Captain stated that he realized that the ILS heading displayed was not 065° but rather 258°, a few seconds before the Tower controller announced that the airplane was not on track. He corrected the error then tried to come back on to the approach track in "heading" mode. The co-pilot stated that he noticed and understood the display error when the Captain made the correction.

A few seconds later, the Tower controller indicated that the airplane was not on track and at the same time, as instructed by the Captain, the co-pilot answered that the airplane was returning to its approach track. The Captain called for flaps extension to 40 and a speed of 150 kt. The co-pilot asked for the ILS to be displayed on the right side. The Captain accepted and the co-pilot displayed the ILS. The Captain stated that he did not check the display.

The "Glideslope" alarm came on when the airplane was in clear skies, according to the FO on LOFT in the observer seat, or had just gone into the fog, according to the co-pilot. According to the crew, the fog was encountered towards 1,500 feet QNH. The Captain stated that during the descent the autothrottles had disconnected and that he had re-engaged them, then re-armed the "autoland" mode, but that the automatic system did not capture the localizer beam.

The Captain decided to perform a go-around as soon as he had the feeling that the approach was not stabilized and that he was below the glideslope track. He called out "TOGA Flaps 15". During the go-around, the FO on LOFT in the observer seat looked at the altimeter and saw 660 feet QNH. The co-pilot looked out of the side window and saw the ground. He then read 50 feet radio-height.

- **End of flight**

According to the Captain, the go-around was performed in manual mode. During the outbound tailwind leg, the co-pilot said he had seen the ground and had read 50 feet on the radio altimeter. The Captain stated that he was amazed by this remark. The FO on LOFT in the observer seat answered that he saw 660 feet on the altimeter. The crew stated that the Tower controller told them that he saw the airplane very low. The go-around, the runway circuit under radar vectoring and the landing in "autoland" mode runway 07 took place with no further problems.

- **Remarks by the crew on the flight**

The checklist and the pre-landing procedure were not carried out.

The Captain did not call out his inputs on the automatic systems. These actions

were performed very rapidly. He did not hear any warnings, either coming from the airplane or the crew or ATC, nor did he hear the Outer Marker signal. He heard no descent or glide deviation information from the crew. He had the impression that the go-around had taken place at the level of the Middle Marker at a height of around 600 feet. He had no notion of height or altitude from the time he selected the "vertical speed" mode when descending. He had no idea at what height he performed the go-around.

The co-pilot did not follow the Captain's inputs on the automatic system until the go-around. He saw the glideslope indicator at the top of the stop and called out "glide" twice. Neither of the FO's on LOFT knew if the Captain heard these callouts. The co-pilot heard the "Glideslope" and "Sinkrate" warnings. He did not hear the Outer Marker signal.

The FO on LOFT in the observer seat heard the GPWS "Glideslope" and "Terrain" warnings. The first GPWS "Sinkrate" or "Terrain" warning sounded when the airplane was in IMC. The crew did not hear a "Pull Up" warning nor the GPWS warning on the height.

Neither the Captain nor the co-pilot nor the FO en LOFT in the observer seat were conscious of any danger at the time of the event.

According to the crew, the airplane instruments functioned normally throughout the flight. Before the approach to Orly, the crew did not hear the GPWS or the "Master Caution" warning at flight level 180.

The Captain informed his Chief Pilot of a go-around in abnormal conditions the same evening.

The two FO's on LOFT stated that, before the event, they were not fully conscious of all of their responsibilities as members of the crew of a commercial flight with passengers.

- **Differences between the witness statements**

The FO on LOFT in the observer seat stated that the first GPWS "Glideslope" warning occurred in VMC whereas the co-pilot stated that it had occurred in the fog.

During the go-around, the FO on LOFT in the observer seat saw ILS tracks 1 and 2 displayed with different values. He stated that the Captain had shown the crew the 258° track displayed on his ILS. The Captain and the co-pilot stated that the ILS selection error on the left side had been corrected before the final descent.

1.18.4.2 Summary of LOC Controller's Statements

The LOC controller was on the Tower 118.700 MHz frequency, in contact with the crew. At the time of the incident, there was fog, no ceiling, and the RVR's were less than 500 meters. The controller couldn't see the runway because of the fog.

The airport was operating under low visibility procedures. The runway 07 ILS was set to category III. The controller was using the approach radar located to his right and the ground radar located to his left. He had to fill out the strips and look over from the approach radar to the ground radar to follow the evolution of departures from 08, their position, the evolution of arrivals on 07 and their position. He also had to watch the information screen to read the latest RVR's before each movement.

- **Event**

At the time of contact, the airplane was on an intercept heading southwest of Orly. It crossed the centreline and followed a track close to the ILS track which took it to the north of the ORW beacon. The controller indicated this positional error to the crew, who responded to him. The airplane rejoined the track just before the Outer Marker. The controller saw a flight level situated between 10 and 19, which made him wonder, taking into account the position of the airplane. He contacted the airplane to ask if it was stabilized. The crew immediately replied that they were performing a go-around. At that moment, the airplane was passing the Outer Marker and the controller saw flight level 04 on the approach radar. After the go-around, he kept the airplane on the frequency and had it perform a runway circuit.

The controller informed his hierarchy of the incident.

- **Controller's remarks**

The controller stated that once the airplane was on the ILS, there were no special instructions at Orly concerning radar surveillance. Many airplane were holding above the airport and were waiting for conditions to improve.

The minima on runway 26 were different from the minima on runway 07.

1.18.5 Technical Information on the MD83

On 23 June 1998, in the presence of the American Accredited Representative, investigators asked Boeing McDonnell Douglas representatives a series of technical questions concerning the MD83. The following information was supplied in response to these questions.

1.18.5.1 Behaviour of the MD83 on Approach with an ILS heading Selection Error

The ILS heading selected by the pilot is used in the lateral directional control law during localizer capture. The control law requires that the selection of the ILS heading be approximately correct to ensure correct localizer capture. In this case, the FMA displays "LOC HEADING" until the system passes over to "LOC TRK" mode. If the ILS heading selection error is sufficiently large, the airplane cannot capture the localizer track correctly. The system remains in "LOC HEADING" mode as long as the localizer signal remains valid.

The airplane manufacturer performed a series of approaches on a development simulator so as to determine from what ILS heading error selection value the localizer capture no longer occurred correctly. From this it was deduced that, under the conditions of the incident flight, an automatic approach is no longer performed when the error is greater than 40°.

With an error of 167° (the error at the time of the incident), if the pilot had not intervened on the airplane's controls by selecting a heading, the airplane would have continued to follow the intercept heading and would have gone off the approach track. If the glideslope track signal had been received after display of "LOC HEADING" on the FMA, the airplane would have begun to capture the glide path, to descend and would have changed over to "GS TRK" mode. The autopilot would have disconnected as soon as one of the two localizer and glide signals had been lost. The horizontal and vertical modes would have remained displayed on the FD.

1.18.5.2 Behaviour of the MD83 in the Conditions of the Incident between 12 h 30 min 03 s and 12 h 30 min 07 s

Note: At 12 h 30 min 03 s, the FMA displayed "LOC HEADING" but did not begin its turn to capture the localizer track. The pilot selected a heading and began to steer the airplane towards the airport.

If the ILS is then selected, the FMA will display "LOC HEADING" again but the airplane will still not turn towards the runway centreline.

If the airplane deviates more than 2.7 points from the localizer before the ILS is selected, the "LOC HEADING" mode will not appear.

1.18.5.3 Additional Information

An uncommanded "LOC HEADING" mode reversion to the "HDG HLD" mode always causes disconnection of the autopilot.

In "Autoland" or in "ILS", the localizer capture mode is identical and acts in the same way.

Manual selection of a heading during approach has the following effects:

- if the ILS or "Autoland" mode is armed, it disarms, then the horizontal heading hold mode engages and the vertical mode becomes "V/S";
- if the autopilot is connected, it remains connected;
- if the "AUT LND" mode is active, manual selection of a heading has no further effect

In "Autoland" mode, disconnection of the auto-pilot will be indicated by an aural and a visual (light) warning until the pilot pushes on the AP disconnect button or reconnects the AP.

Mode reversion following a pilot action will be indicated on the FMA by three flashes on the display.

When the vertical speed wheel is activated very rapidly in one direction (up or down) it is possible for the system to interpret the movement in the opposite direction. This phenomenon was detected during test flights and noted in service. An All Operator Letter which explains this phenomenon was sent to all airlines (see appendix 11).

If the "Autoland" mode is armed, the disconnection of the autopilot will result in an ILS mode reversion. If the AP is re-connected, the ILS mode will be taken into account.

Signals Recorded by the QAR

The two signals coming from the GPWS recorded on the QAR were sent to the FDAU. They came from two warning lights in the cockpit: "GPWS" and "Below GS". The "Glideslope" warning recorded on the QAR corresponded to the "Below GS" light and was associated with an aural "Glideslope" warning. The "Terrain" warning recorded on the QAR corresponded to the "GPWS" light. It illuminates when the GPWS aural warning initiates, except for the "Glideslope" and "Minima" warnings and the height announcements. These aural warnings are, for example, "Terrain Terrain", "Pull Up", "Sinkrate", "Don't Sink" (takeoff only), and «Too Low - Terrain" (on flap retraction), "Too Low - Flaps", or "Too Low - Gear".

Management of alarms in the Cockpit

There are three sources of aural warnings in the cockpit; the CAWS (Central Aural Warning System), the GPWS and the TCAS (Terminal Collision Avoidance System, not installed on the airplane). Each of these sources has its own independent loudspeakers installed in the cockpit. The aural warnings are not transmitted on the headsets.

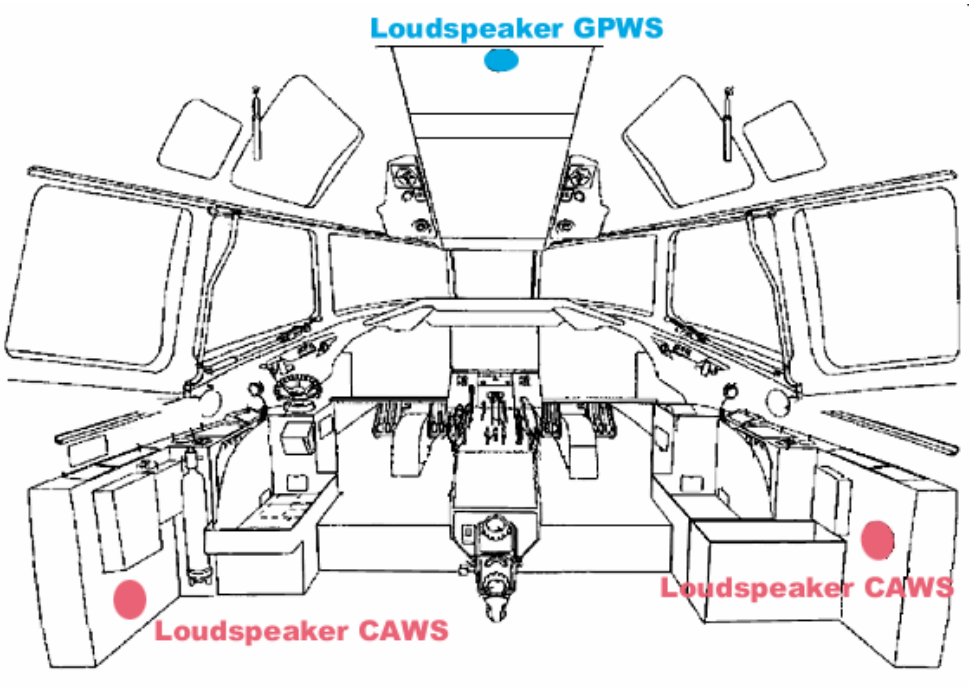


Figure 11

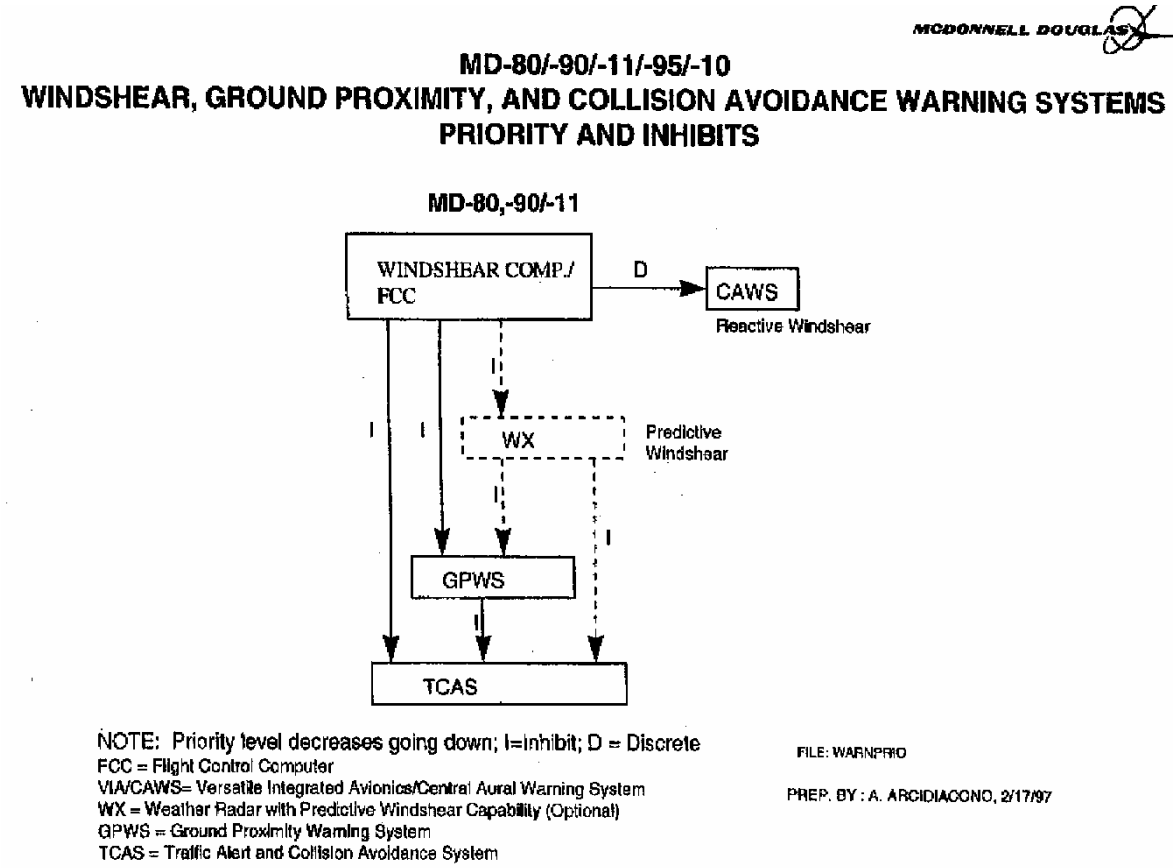


Figure 12

CAWS

Each warning signal produced by the onboard systems and sent to the CAWS is placed on hold. Each warning has a defined level of priority. The warnings with the

highest priority are placed ahead of the low priority warnings. The warnings remain active and are repeated as long as the onboard system generates them.

The warning priorities are:
- "Tailwindshear", "Windshear", "Stall" (level 1 is the highest)
- "Headwindshear" (level 2)
- "Autopilot" (level 3 only for the first appearance of the alarm)
- all the other warnings (level 4 the lowest), including the altitude warnings and later appearance of the AP disconnect warning.

When an altitude aural warning is generated, it is heard every 0.8 seconds ("C chord" sequence followed by the "Altitude" announcement) and the altitude warning light remains illuminated until the pilot cancels it.

The warnings generated by the CAWS have three volume levels. The lowest (level 3) is used on the ground and at speeds under 50 kt. The loudest (level 1) is used during approach and landing phases. It is reduced (level 2) when the landing gear is retracted and the speed is greater than 210 kt in cruise.

GPWS

The volume of warnings generated by the GPWS is unique. The "Low Volume Glideslope" and "High Volume Glideslope" warnings differ in frequency and repetition.

The following table shows the comparative volume in dB of warnings compared to CAWS level 3:

CAWS		**GPWS**
level	volume	volume
1	+12 dB	+13 dB
2	+4 dB	
3	0 dB	

Windshear and TCAS systems are not installed on the AOM Minerve S.A. fleet. CAWS and GPWS warnings can sound simultaneously.

Appearance of "ALT HLD" mode on the FMA

According to the manufacturer, there are three possible explanations for the appearance of the "ALT HLD" at 12 h 31 min 56 s:
- the pilot selected the "ALT HLD" mode,
- the system recorded the code corresponding to the "VERT SPD" mode badly, which differs by only one bit from the "ALT HLD" mode code,
- the pilot moved the vertical speed wheel to a position close to zero, which activated the "ALT HLD" mode.

Appearance of "EPR MCT" mode on the FMA

It was not possible to reproduce the appearance of the "EPR MCT" mode on the

FMA during go-around in the manufacturer's laboratories. One unconfirmed hypothesis is that the pilot may have previously selected the MCT mode on the TRI.

Precision Approach

The Captain was qualified for category III approaches, the co-pilot was qualified for reduced category I approaches, the airplane was equipped to perform category III approaches.

The crew was authorized to undertake approaches in the lowest of the three preceding categories, that is to say reduced category I.

2 - ANALYSIS

2.1 Incident Scenario

Toulon-Orly morning flight

At 8 h 8 min 41s, on first contact with Orly Approach, the first officer (in the observer seat during the incident flight) announced a category III approach for runway 07, although the crew was only rated for restricted category I approaches. At 8 h 23 min 06s, as the crew was preparing to begin the descent from 3,000 feet towards the runway, Orly Tower informed them of a change of runway: runway 26 was put into service as a result of a ground lighting problem on runway 07.

At 8 h 24 min 40s, Orly Tower informed them of an RVR of 650 meters for runway 26. At 8 h 37 min 30s, though the crew announced having passed the Outer Marker three minutes previously, Orly Tower indicated an RVR of 400 meters. At 8 h 38 min, the airplane landed on runway 26 in Autoland mode, meaning with only one autopilot active and the other functional and ready to take over.

Incident flight

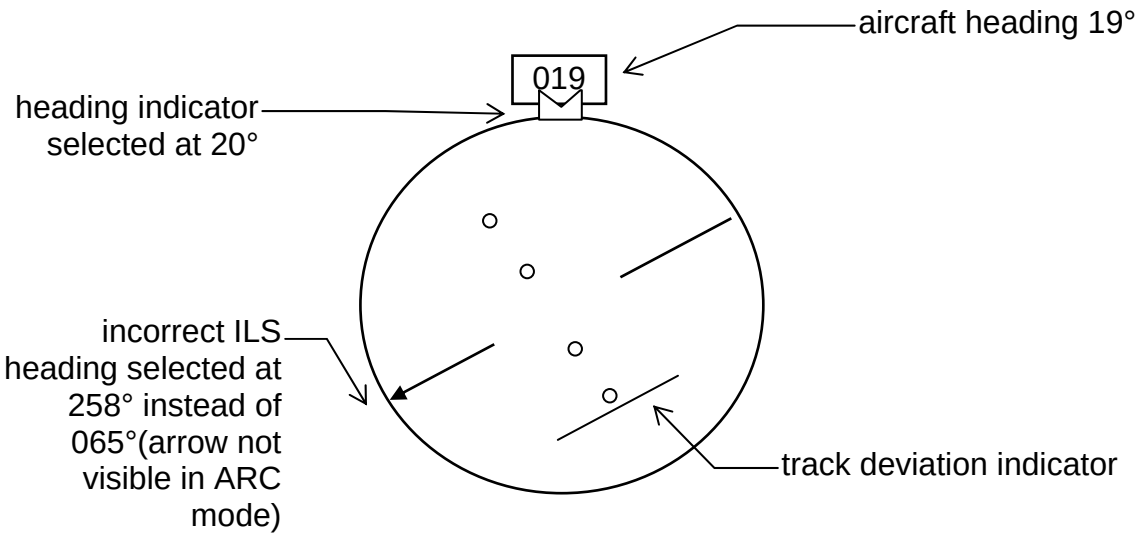
At 12 h 26 min 23s, on approach to Orly, the Captain selected a track of 258° instead of 065° on the ILS 1. The selection error was probably due to confusion between runway 07 and runway 26 with a 258° track which he had used on the morning flight. The co-pilot did not check the selection. The Captain used the "ARC" mode on the HSI.

At 12 h 28 min 33s, when the Captain armed the Autoland mode, the FMA displayed the following information:

engine mode (green)	armed mode (amber)	horizontal mode (green)	vertical mode (green)
LOW	AUTOLAND	HEADING	VERTICAL SPEED

LIM	ALTITUDE		

At 12 h 29 min 36s, intercepting the runway 07 ILS, the runway line-up deviation indicator began to move. A simplified representation of the Captain's HSI would show (the HSI is shown throughout in "ROSE" mode for more legibility):

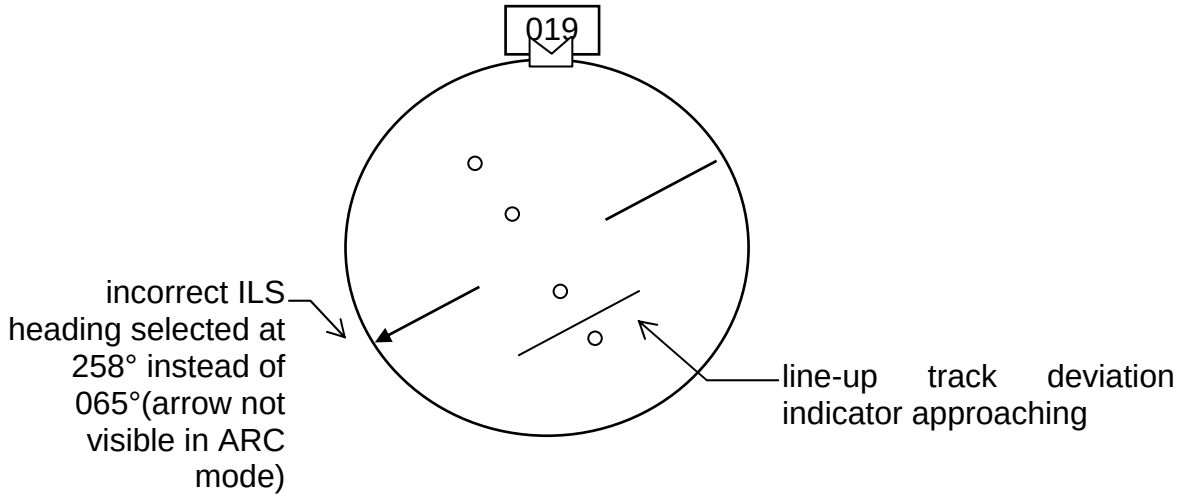


The FMA showed the following information:

engine mode (green)	armed mode (amber)	horizontal mode (green)	vertical mode (green)
SPEED	AUTOLAND	HEADING	ALTITUDE HOLD

The flight director trend bars were centred.

At 12 h 29 min 43 s, the LOC capture mode was displayed on the FMA. At that moment, a simplified representation of the Captain's HSI would show:

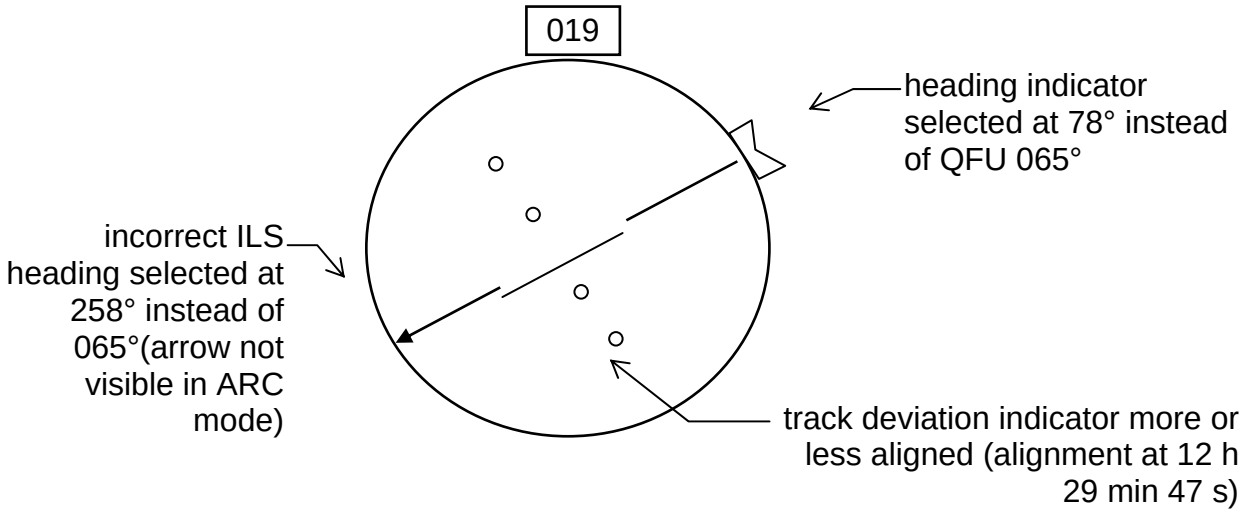


The FMA displayed the following information:

engine mode (green)	armed mode (amber)	horizontal mode (green)	vertical mode (green)
LOW LIM	AUTOLAND	LOCALIZER CAPTURE	ALTITUDE HOLD

The flight director trend bars were still centred.

The Captain believed he was bringing the heading indicator up in line with the head of the ILS indicator arrow, but in fact he was he was bringing it to the tail of the ILS. He then noticed that the heading indicated 78° whereas he expected the QFU of runway 07. He tried to understand the difference between the expected heading and the displayed heading, which increased his workload. From this moment on, he was working alone. The co-pilot, who was no longer informed of the situation, could no longer understand the Captain's actions. A simplified representation of the Captain's HSI would show:



The FMA displayed the following information:

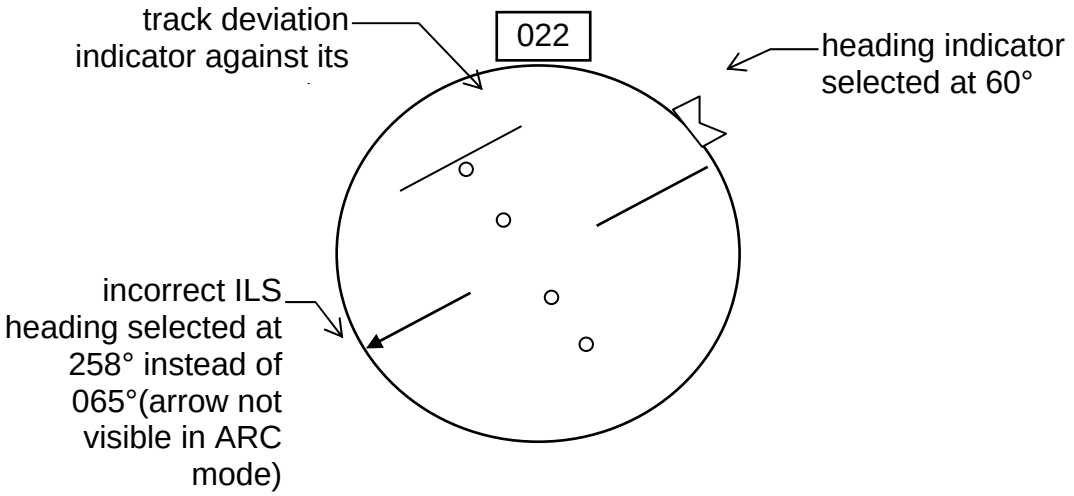
engine mode (green)	armed mode (amber)	horizontal mode (green)	vertical mode (green)
LOW LIM	AUTOLAND	LOCALIZER CAPTURE	ALTITUDE HOLD

The flight director trend bars were still centred.

Due to the error in the ILS heading selection and despite the FMA display, the automatic system did not capture the localizer beam and the airplane maintained its heading. The Captain noticed the inconsistency between the FMA display and the airplane's behaviour but did not yet understand the reason.

At 12 h 29 min 57 s, the track deviation indicator reached its stop. Two seconds later, the Captain selected a heading of 60° on the DFGS, probably to return

towards the localizer track which he believed to be to the left, with a heading close to the approach track. In fact, he still had not realized that the tip of the ILS heading selection arrow was pointing more or less 180° away from the ILS heading. In this configuration, the localizer track was displayed on the left on the HSI. This selection caused disarming of the "Autoland" mode, and replaced the "LOC CAPTURE" mode with "HEADING" mode. Note that if the Captain had not selected any heading, the airplane would have continued on a constant bearing without ever intercepting the localizer track. A simplified representation of the Captain's HSI would show:



The FMA displayed the following information:

engine mode (green)	armed mode (amber)	horizontal mode (green)	vertical mode (green)
LOW LIM		HEADING SELECT	ALTITUDE HOLD

The flight director trend bars were still centred.

At 12 h 30 min 01 s, the Captain armed the "ILS" mode then the LOC CAPTURE" mode was displayed on the FMA. However, in this configuration, (airplane moving away from the approach track and ILS heading selection error), the automatic system still could not capture the localizer and the airplane remained on a constant heading. The FMA displayed the following information:

engine mode (green)	armed mode (amber)	horizontal mode (green)	vertical mode (green)
SPEED	ILS	LOCALIZER CAPTURE	ALTITUDE HOLD

At 12 h 30 min 07 s, the Captain again selected the "HEADING" mode on the same heading of 60°, which resulted in the disarming of the "ILS" mode and replacement of the "LOC CAPTURE" mode by the "HEADING" mode. The Captain had still not realized his error in the ILS heading selection. The FMA displayed the following information:

engine mode (green)	armed mode (amber)	horizontal mode (green)	vertical mode (green)
SPEED		HEADING SELECT	ALTITUDE HOLD

At 12 h 30 min 20 s, the airplane passed above the approach track. The Captain realized that he was to the left of the localizer track and above the glideslope track. At 12 h 30 min 29 s, he armed the "ILS" mode. At 12 h 30 min 40 s, he armed the "AUTOLAND" mode, selected a preparatory go around altitude of 2,000 feet, selected a descent rate of around 2,300 feet per minute, a heading of 90° and a final approach speed of less than 149 knots (in fact 149 knots was the minimum speed recorded by the QAR during the descent and at this speed, the autothrottle always keeps the engines idling towards a selected speed, thus a lower one). The Captain decided to capture the glideslope track from above at the same time as capturing the localizer by turning to the right with an interception angle of around 20°. From this time on, he concentrated all of his attention on intercepting the localizer and was no longer conscious of the airplane's position in the vertical plane.

Following these actions, the FMA displayed the following information:

engine mode (green)	armed mode (amber)	horizontal mode (green)	vertical mode (green)
LOW LIM	AUTOLAND	HEADING SELECT	VERTICAL SPEED

The flight director trend bars were still centred.

The airplane came back towards the approach track and descended in clear skies.

The Captain realized that he had selected an ILS heading of 258° and corrected it. He continued the approach. He was then waiting to come back onto the localizer track, with the HSI localizer deviation needle against its stop to the right. He had the ADF and the flight director trend bars, still centred, available for consultation.

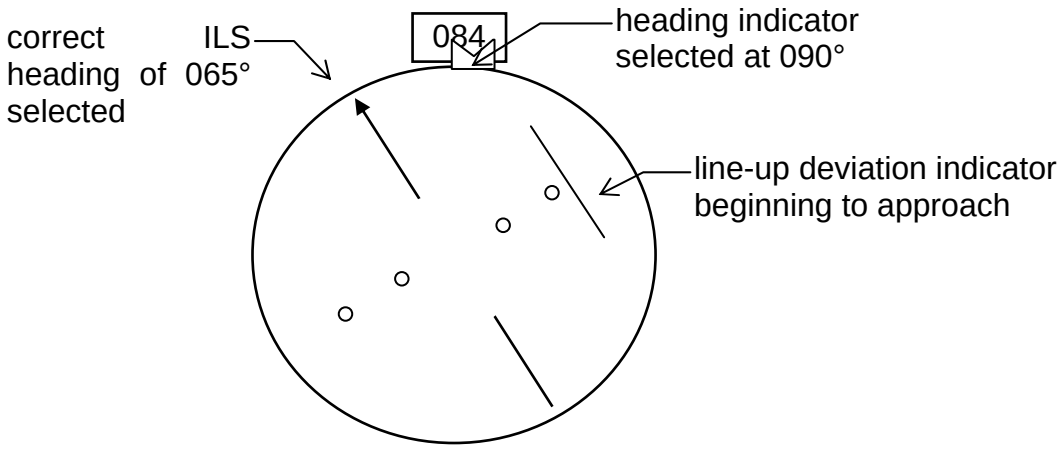
At 12 h 31 min 6 s, the airplane passed below the glideslope track. At 12 h 31 min 19 s, the airplane went past 1,750 feet QNH and the altitude alert sounded. It is impossible to say whether the crew cancelled this alarm. At 12 h 31 min 26 s, at a radio altitude of 916 feet, the GPWS "Low Volume Glideslope" alarm triggered. At 12 h 31 min 28 s, the Captain disconnected the autopilot. Consequently, the "Autoland" armed mode was automatically replaced by "ILS" armed mode and the autopilot disconnection alarm triggered and was superimposed over the already active GPWS alarm. It is impossible to say if the crew cancelled the autopilot alarm.

The FMA displayed the following information:

engine mode (green)	armed mode (amber)	horizontal mode (green)	vertical mode (green)
LOW LIM	ILS	HEADING SELECT	VERTICAL SPEED

At 12 h 31 min 30 s, at a radio-height of 783 feet, the "Sinkrate" alarm triggered for two seconds. The "Low Volume Glideslope" alarm was again triggered at the end of the "Sinkrate" alarm.

At 12 h 31 min 30 s, the airplane descended through 1,250 feet QNH and the altitude alarm triggered again and was superimposed on the GPWS alarm. It was not cancelled by the crew, and continued to sound until the airplane reached 1 250 feet QNH in climb after the go around. At 12 h 31 min 30 s, the "LOC capture" mode was displayed on the FMA and the localizer beacon indicator, until then at its stop to the right, began to move. The flight director, which was centred until that time, then indicated to the pilot the trajectory to follow to rejoin the localizer track. The Captain turned the airplane left to intercept the approach track:



The FMA displayed the following information:

engine mode (green)	armed mode (amber)	horizontal mode (green)	vertical mode (green)
LOW LIM	ILS	LOCALIZER CAPTURE	VERTICAL SPEED

At 12 h 31 min 49 s, the Captain connected the autopilot at a radio-height of 415 feet, probably because he saw "LOC CAP" displayed on the FMA and thought he could still carry out the approach. He then armed the "Autoland" mode. The FMA displayed the following information:

engine mode (green)	armed mode (amber)	horizontal mode (green)	vertical mode (green)
LOW LIM	AUTOLAND	LOCALIZER CAPTURE	VERTICAL SPEED

At 12 h 31 min 54 s, at a radio-height of 279 feet, the "Sinkrate" alarm triggered again for seven seconds and was superimposed over the altitude alarm which was still active.

At 12 h 31 min 56 s, the Captain disconnected the autopilot, probably because he no longer thought it possible to stabilize the airplane. The AP disconnection alarm mixed in with the altitude alarm and was superimposed over the GPWS alarm. The AP alarm was not cancelled by the crew until an altitude of at least 1,250 feet QNH after the go around. The Captain began the go around at a radio-height of around 200 feet.

2.2 Captain's Actions

In the course of the incident, the Captain lost awareness of the airplane's position in the vertical plane. Even the go around was performed without him having realized how low his altitude was. This loss of awareness of the vertical position of the airplane can be attributed to his concentration on horizontal navigation.

Several decisions led to the incident. First of all, the Captain undertook, as he probably had during the morning flight, a category III approach with a crew who did not have the necessary ratings. He did not state his intended actions to the inexperienced co-pilot, whom he considered to be a student and who thus became a simple spectator. He put the airplane into descent without having stabilised on the localizer beam while he was below the glideslope track. Finally, rather than interrupting the approach, he continued with it while trying to understand what was going wrong.

The Captain's concentration on the horizontal plane resulted from a problem of understanding the airplane's horizontal navigation system. In fact, at the moment of track interception, the behaviour of the airplane and the information supplied by the FMA were not consistent. His attempts to resolve the problem by returning to the basic mode then by attempting another capture in automatic mode proved fruitless. In addition, when faced with a problem, he ignored the co-pilot. His workload thus became heavier, notwithstanding an already high level of fatigue. His performance therefore deteriorated. He could not solve all of the problems at the same time and concentrated on the one concerning his position in the horizontal plane. Finally, neither the alarms, which were too numerous, too frequent and which superimposed over each other, nor the visual information on the control panel, nor his trainees, who were too confident and too inexperienced, drew his attention to the vertical plane.

The Captain performed the go-around when he felt he would no longer be able to stabilize the airplane before landing and that he was below the glideslope track. He was never aware of the airplane's height. All of the protective systems against a collision with the ground failed. Only the Captain's intuition prevented an accident.

2.3 Crew Behaviour

Throughout the day, two priorities seemed to dominate the crew, carrying out commercial flights and the accelerated training of the two first officers on line orientated flight training (LOFT). This attitude can scarcely be accidental. It more likely represents the general objectives of the airline, faced as it was by the dual challenge of the urgent training of a large number of pilots to counter a shortage resulting from earlier decisions, and the necessity to complete its commercial flight program.

The Captain acted alone. The co-pilot was aware of a problem in the vertical plane because he announced the glideslope track and looked outside. The first officer in the observer seat was also aware of an abnormal situation. However, neither of them intervened. Several factors contribute to an explanation of inadequate crew performance:

- The two first officers in training had an MD83 type rating but had not yet finished their LOFT.
- They had very little experience, unlike the Captain, which generated a passive attitude on their part.
- The functions of the trainee first officer in the observer seat were not clearly defined, either by the airline or by the Captain. She neither had the role of backup co-pilot, nor the competence to perform the task. She had, however, performed this role for another airline on a different type of airplane.

During the approach, the two first officers on LOFT behaved like students facing an instructor. They were unaware of their responsibilities in the conduct of a commercial flight. Their attitude was passive, although the Captain was demonstrating a landing in poor visibility. The context of a learning situation inhibited CRM. They never had the feeling of being in any danger.

In conclusion, the Captain had to perform the roles of captain, co-pilot and instructor during the incident flight. There was no check of the Captain’s actions or decisions, nor any mutual crosschecking. Neither the role of co-pilot responsible for safety nor the role of first officer were filled on board the airplane, which is unacceptable from the point of view of the safety of a passenger-carrying flight.

Note: The backup co-pilot referred to above corresponds to the current notion of "a member of the crew designated and trained for supervision" (law of 15 February 1999 concerning the conditions for airplane operated by an airline).

2.4 Crew Flying Hours

Clearly, operators must monitor their pilots flying hours, for example to check their training and to plan flights. However the number of flying hours recorded by the airline was different from those really performed. Its system for managing flying hours was inadequate. It did not reproduce the activity report. The system recorded the number of hours spent on board a plane (whatever the position of the person on the airplane) but did not take into account the post occupied on the airplane. It was quite possible to find more than two pilots on the same flight. The

airline could not therefore precisely know the number of flying hours of its pilots according to the regulations in force. It could thus not respect the provisions of its operations manual either.

The flight crew were responsible for their own personal duty time accounts. However, some of them, including the Captain, used the airline flying hours entries to account for their flying hours in their flight log. Since the entries were false, they could not know whether they were conforming to the regulations or not.

On several occasions, the Captain's flying hours exceeded the statutory limits:

95.58 flying hours from 16 August to 15 September and 104.77 flying hours from 16 October to 15 November, while the statutory limit is 95 hours.

181.5 flying hours from the 1 July to the 31 August, while the statutory limit is 180 hours.

271.12 flying hours from 1 July to the 30 September and 267.77 flying hours from 1 August to 31 October, while the statutory limit is 265 hours.

The co-pilots on LOFT, like the airline, counted flying hours even when they were in the observer seat. They thus obtained their first officer rating when their real flying hours were lower by around 25% than the hours declared. Under these conditions, some young first officers did not have the minimum number of flying hours required relative to the program registered by the airline and thus probably did not possess the skills to carry out this role.

2.5 Captain's Fatigue

An instruction flight generates a higher level of fatigue than a normal flight. What is more, in the case of the Captain, the regulations allowed him to undertake simulator sessions as well as hours of work on the ground which were not counted as work time. In these circumstances, it is thus possible for high levels of fatigue to build up while respecting the regulations concerning working hours. Fatigue is a significant factor in relation to safety. It can reduce pilot effectiveness, causing a significant increase in the number of errors.

Concerning the incident itself, the Captain had built up a high level of fatigue due to the number of flights as instructor, the simulator sessions, work on the ground and exceeding the regulatory number of flying hours. This apparently contributed to the ILS heading selection error and diminished his performance when faced with a situation requiring a high workload.

2.6 Crew Training

The presentation and use of information on the control panel is different on conventional instruments and cathode ray tube displays. Specific adaptation is therefore required to pass from one to the other. In the case of AOM Minerve S.A., this adaptation initially concerned experienced pilots. It was not suited to co-pilots

on LOFT because they lacked experience. It did not allow them flights on EFIS airplanes. This situation was aggravated by the failure to respect the oral agreement with the civil aviation directorate (DAC) which specified that co-pilots who had been trained on simulators with conventional instruments should perform their first LOFT flights on "glass cockpit" airplanes.

To summarize, the training for MD83 first officers on airplane with cathode ray tube displays was inadequate.

2.7 Control Panel Ergonomics and Airplane Behaviour

At the time of the interception of the localizer beam with a track selection error of around 180°, the FMA indicated that the airplane was in localizer capture mode (LOC CAP) when in fact it was not capturing it. When the Captain noticed that the airplane was not capturing it, he had two contradictory pieces of information at his disposal: the deviation indicator at its stop on the HSI and "LOC CAP" displayed on the FMA. This contradiction disturbed him. In addition, if he had not gone back to "HDG" mode, the airplane would not in fact have intercepted the localizer but would probably have captured the glideslope. It would then, paradoxically, have descended on the glideslope several dozen degrees from the runway centreline with the FMA displaying "LOC CAP", G/S TRK).

In certain circumstances, such as those in the incident, the FMA can generate false information ("LOC CAP" although the airplane is not going to capture the localizer or the localizer signal has been lost) in a critical situation (final approach or undetected error in ILS heading selection). This information disturbed the pilot. A simple ILS heading selection error caused this problem and would systematically be reproduced on the MD83.

However, French specifications on this point indicate "LOC capture priority versus GS capture in ILS capture". This formulation is imprecise. It does not clearly state what is required technically, that’s to say that the localizer must really have been captured and followed, before the system can capture the glideslope track. It is clear that the airplane manufacturer did not understand this or believed that the aircraft, already certificated in the USA, met this specification. Whatever the case may be, a flaw in the airplane was thus not brought to light. In fact, on the MD83, the FMA actually indicates "LOC CAP" before "G/S CAP". As the research which followed the incident showed, this does not mean that the airplane will capture the localizer before the glideslope, only that it will be in localizer capture mode before passing to glideslope capture mode.

The ILS heading selection error is detectable in three ways:
- digital display on the DFGS
- direction and relative position of the arrow on the HSI
- anti-directional indication of the localizer deviation bar on the HSI.

In the case of this incident, the display had not been checked by the co-pilot on the DFGS. In accordance with procedures, the Captain checked the track with the aid of the HSI. Since the error was of the order of 180°, the relative position of the

arrow was correct; he did not realize that it was pointing in the wrong direction. The indication of direction is less visible than its relative position, particularly in ARC mode, which the Captain was using.

The simulation of the event brought to light several problems. First of all, there were too many alarms at the same time and the crew was overwhelmed. Next, there was no system for alarm priority or alarm intensity management. As a result, the crew failed to hear certain height announcements and failed to notice some GPWS alarms. Finally, the sheer frequency of the alarms was such that they were rendered ineffective.

To summarize, the absence of alarm management in the cockpit meant that the last safeguard against collision with the ground, the GPWS, was rendered ineffective. When they are superimposed, too many independent alarms lose their effect and even disturb the crew.

2.8 Controller's Actions

It was impossible to determine what the air traffic controller saw on his screen, since this basic information is not recorded, though it would have been useful for the investigation. We can, however, try to explain why the controller noticed the lateral deviation of the airplane very quickly but only noticed its vertical deviation very belatedly.

Firstly, the controller is not supposed to watch airplanes closely on approach. He had other tasks to perform (managing airplane taxiing, managing takeoffs, filling out flight progress strips and supplying meteorological information - which provides a heavy workload in poor visibility) which diverted his attention from the airplane on approach.

In addition, the radar plots indicate flight levels while, on approach, crews use altitude information. For a given altitude, the flight level can vary by a factor of plus or minus 10 according to atmospheric pressure. This indication is not sufficient to warn the controller of an airplane at too low an altitude.

There is a system which could have warned the controller if it had been installed at Orly: the MSAW, which has already been installed in Lyon. The results of the simulation show that it would have alerted the controller of the airplane's dangerous proximity to the ground thirty seconds before the go around, when the airplane was at 900 feet.

2.9 Airline Oversight

The Flight Inspection Service performed three in-flight inspections during 1997, two on DC10's and one on MD83. More frequent inspections would certainly have brought to light some failings, but these inspections were far too infrequent in 1997 as far as the MD83 sector was concerned.

The investigation showed that numerous failings in the airline had been detected. These failings were not penalized by the Civil Aviation Directorate (DCA) since it has a very limited number of possible penalties at its disposal, with severe consequences (suspension of the Air Transport Certificate). In most cases, since the consequences of an effective penalty seem disproportionate to the failings identified, the DAC limits itself to issuing warnings. The progressive accumulation of failings, however minor, can lead to a serious event. However, they are rarely penalized and thus probably not corrected. Because the range of penalties is not sufficiently progressive, safety objectives are not met.

2.10 Meteorological Information during Flight Preparation

TAF's are invalidated as soon as a METAR contains a significant difference. On the day of the event, the TAF should have been modified for Paris Orly and Paris Charles de Gaulle, something that was not done because of a lack of a systematic procedure.

During preparation for the flight, since the TAF and the METAR for Paris Orly gave contradictory information, the Captain, as he was allowed to do according to regulations, took account of the least limiting one from the operational viewpoint, meaning the TAF. However, the trend in the METAR, always of better quality since more up-to-date, indicated unfavourable conditions for a decision to carry out the flight. Conscious that the meteorological conditions at the destination airport and the alternate airport might not permit a landing, the Captain took on sufficient fuel to be able to return and land in the south of France if necessary. As the event showed, it is difficult to take the decision to turn back when already at the destination airport and the conditions are only marginal.

2.11 Use of Minima during a Precision Approach

Precision approaches are based on the minima. During the morning flight, the last RVR transmitted to the crew twelve minutes before passing the outer marker (OM) allowed them to continue their approach. Subsequently, nine minutes before passing the OM, it went below 450 meters and worsened progressively. Information concerning this breaching of the minima (500 meters) should have led to the crew aborting the approach, but was not transmitted to them in time. It should be noted that the Orly operations manual specifies that the controller should inform the crew of any new RVR's at the Outer Marker if they have worsened, which was not done at the time of the morning flight.

According to the ATC regulations, the controller should supply RVR's at each significant change, though this is difficult in rapidly changing meteorological conditions.

In marginal meteorological conditions, the crew decides to continue the final approach according to several criteria, including the RVR at the runway threshold which must be above a minimum level at a precise point on the approach (above the OM for Orly). However, ATC does not provide RVR's at a precise position of

the airplane, but rather at the beginning of the approach then theoretically at each significant change. The ATC procedure and the crew's procedure do not really correspond. Equally, it was noted that, at Orly, the specific procedure for communicating the RVR's at the OM does not ensure that the crew would in fact have this information before passing this point, which would lead them to continue with the landing.

2.12 Charts Used in Flight

The Jeppesen chart which the crew used, as specified in their operations manual, does not correspond to the official AIP chart. Although the IAC and TMA charts are the only official charts, they are not mandatory. In fact, the official charts are not used by the majority of airlines around the world, as they prefer to use Jeppesen charts, which are as we have seen more practical, but whose content is not always valid. The company which publishes the Jeppesen documents guarantees the precision of the information and procedures it describes, but no independent organization checks that these documents conform to those issued officially. It is surprising that no approval procedure exists at the level of IATA.

2.13 Flight Recorders

To understand the event, it was necessary to generate hypotheses on the information provided to the crew in the cockpit, crew actions relative to systems, crew workload and functioning, as well as on the precise moment when flight conditions changed from IMC to VMC. Data provided by the QAR (identical to that from an FDR) did not make it possible to answer these questions.

The same problems were encountered during the investigation into the accident at Mont Saint Odile in 1992. The recorded information did not make it possible to determine what the crew's actions had been on the airplane's vertical mode.

Readout of the GPWS BITE showed two types of alarms: "Glideslope" and "Sinkrate". Simulations by the manufacturer confirmed that the "Low Volume Glideslope", "Sinkrate" and "High Volume Glideslope" alarms had probably been triggered. The two GPWS alarms ("Glideslope" and Terrain") recorded on the QAR corresponded respectively to the illumination of the "Glideslope" and "Warning" lights on the control panel.

Furthermore, the simulation was the only thing which made it possible to determine with any certainty which alarms were triggered during the incident. A simple readout of the QAR would have led to confusion between the auditory and visual GPWS alarms, and thus to a false interpretation of the event, even more so given that the first officer under training in the observation seat noticed an alarm of the "Terrain" type.

2.14 Notification of Incidents

Those involved in this incident, whether the crew or the controller, did not immediately perceive the gravity of what had happened. The first officer had seen the ground and had seen around 50 feet displayed on the radio altimeter, but during the downwind flight which followed the incident, the first officer in the observer seat stated he read 660 feet on the altimeter and the crew convinced themselves that the airplane had not descended so low. They had not therefore notified the incident to the authorities. However, the Captain informed his chief pilot of a go-around in abnormal conditions the same evening. On his side, the controller informed his hierarchy of the incident, but the information was not forwarded to the BEA.

Following the information given by the Captain, the airline management asked for their flight analysts to read out the QAR rapidly. It was this readout which showed the seriousness of the event. This explains why the BEA was only informed of the incident four days after it occurred. In the meantime, however, informal contacts had apparently taken place with several people in civil aviation circles, who were not, as it happened, specialised in the domain.

This is a clear breach of the Civil Aviation Code, which specifies that any event which may have jeopardized the safety of a flight must be notified immediately. Of course, we might consider that the dialogue between the pilot and the controller could appear to be a notification of the event. However, in that case, the Captain should have sent a report to the BEA within 48 hours, something which he did not do either. In addition, we note a delay in the transmission of information once the seriousness of the event had been established. It would appear that there is a tendency to consider that only particularly serious events must be notified to the BEA, perhaps after the beginning of an analysis, whereas the objective of notification is, on the contrary, to make it possible, if necessary after consultation, to decide on the immediate launching of an official investigation.

3 - CONCLUSIONS

3.1 Findings

- The airplane was certified and maintained in accordance with the regulations in force.

- The crew possessed the requisite licenses and qualifications to undertake the flight. They were qualified to perform restricted category 1 approaches.

- The operator had decided to train a large number of crews urgently to deal with a shortage which had existed for several months.

- The two First Officers present in the cockpit were undertaking line orientated flight training. The Captain was a qualified instructor.

- The operator did not know the exact number of flight hours performed by the flight crew.

- The Captain’s level of fatigue was high.

- The forecasts contained in the TAF and the METAR used by the crew to prepare the flight were different. This difference was greater than the TAF modification criteria.

- The TAF allowed the crew to undertake the flight in accordance with regulations.

- The Captain was the pilot flying during the approach. He selected an incorrect ILS heading. This error went unnoticed by the crew.

- The term "LOC CAP", in other words Localizer Capture mode, was displayed on the FMA while the automatic flight control system, bearing in mind the selection error, made it impossible for the airplane to capture the localizer track.

- In this configuration the airplane, even though it had not captured the localizer, was able to follow the glide path, in other words was able to descend. This point had apparently never come to light previously.

- French specifications relative to ILS capture lack clarity. They lack the element of compulsory application.

- During the approach, the pilot’s workload was very high. Once the airplane had moved left of the localizer track, the pilot no longer stated his intentions to the co-pilot.

- The Captain, noticing a problem, turned the airplane by selecting the Heading mode, then began descending. At that moment, the airplane was above the glide path.

- During the descent, the co-pilot made no comments to the pilot.

- During the descent, the pilot lost vertical positional awareness. He was concentrating his attention on the horizontal plane.

- During the descent, the pilot did not hear the GPWS, altitude and AP disconnect alarms.

- The CAWS and the GPWS generate warnings independently. These occurred simultaneously during the descent.

- The pilot was not conscious of the airplane's very low height at the moment he performed the go-around.

3.2 Probable Causes

The incident resulted from the decision to put the airplane into descent when, as a result of a display error, it was neither on the localizer track nor on the glide path, and with no context defined for this improvised manoeuvre.

The importance that AOM attached to accelerated training given to new co-pilots and to undertaking commercial flights contributed directly to the incident.

Other contributory factors were:
- the pilot's fatigue;
- the imbalance in the flight crew, made up of a very experienced instructor and an under-trained co-pilot, which led to the abrupt disappearance of teamwork and procedures the moment the workload increased;
- airplane warning system ergonomics and a fault in the automatic pilot system.

4 - RECOMMENDATIONS

4.0

The preliminary report on the incident contained six safety recommendations, reproduced below.

The investigation is not complete. However, taking into account the facts determined thus far, the BEA considers it necessary to issue certain recommendations.

During the investigation, even if it played no role in the development of the incident, it was noted that:

- *the IAC chart for an ILS instrument approach to runway 07 at Paris Orly on 17 July 1997 indicated, in a box: "beginning of descent on radar clearance 7.8 NM OL at 2000 (1711)".*

- *the Jeppesen instrument approach chart 11-2A of 6 June 1997 indicated, in a box: "radar monitoring during final descent starts at 2000 (1711) D7.8 OL". This information is different from that of the official chart.*

Jeppesen charts are not an official publication. However Jeppesen, in its guarantee; "expressly warrants that it has accurately graphically depicted the flight procedure prescribed by applicable government authorities…." In addition, the charts are used constantly by the majority of public transport pilots.

Consequently, the BEA recommends:

- ***that Jeppesen make its Orly approach chart compatible with the official French chart.***

In the Orly METAR trend information at 10 h 00, an improvement of visibility from 450 to 800 meters was forecast. In that of Roissy, no significant change was forecast. In the Orly and Roissy TAF 0918 an improvement in visibility up to 2,000 meters was forecast between 9 h 00 and 11 h 00.

There was no modification to the TAF despite the inconsistency with the METAR trend.

Consequently, the BEA recommends:

- ***that Météo-France remind forecasters that they must amend TAF's whenever a threshold amendment is forecast.***

During preparation for the flight to Marseille, the Orly METAR trend information at 10 h 00, was not taken into account by the crew.

Consequently, the BEA recommends:

- ***that the DGAC ensure that pilot training clearly demonstrates that the majority of METAR's contain trends, which are meteorological forecasts valid for two hours, and can be used for the preparation of flights of short duration,***

- ***that the DGAC remind crews that in case of uncertainty or of contradiction between different parts of the meteorological file, they can obtain direct information from the meteorological centre.***

On several occasions, the Captain's flying hours in 1997 (see paragraph 1.5.1.1) exceeded the limits set by Regulation n° 97-999 of 29 October 1997:

95.58 flying hours from 16 August to 15 September and 104.77 flying hours from 16 October to 15 November, while the limit is 95 hours.

181.5 flying hours from the 1 July to the 31 August, while the limit is 180 hours.

271.12 flying hours from 1 July to the 30 September and 267.77 flying hours from 1 August to 31 October; while the limit is 265 hours.

Consequently, the BEA recommends:

- ***that the DGAC ensure that airlines possess information which allows them to modify flight planning so as to avoid pilots exceeding the statutory work time.***

During the approach, the Tower controller noticed an anomaly when reading off the flight level. He contacted the crew when the go-around had started. The Orly ATC organization is not yet equipped with the MSAW system.

In accordance with recommendation 42.3 of the report of the Commission of Inquiry into the accident at Mont Sainte Odile on 20 January 1992, the MSAW (Minimum Safe Altitude Warning) system, installed at Lyon since 19 June 1997, is being installed at other aerodromes. The objective of this system is to allow ATC to inform the crew of an aircraft in case of dangerous proximity to terrain.

Consequently, the BEA recommends:

- ***that the DGAC accelerate installation of the MSAW system and prioritize aerodromes with heavy traffic.***

4.1

The analysis found that the Captain was highly focused on lateral navigation, to the detriment of attention paid to the vertical trajectory.

The Commission of Inquiry into the accident at Mont Sainte Odile which occurred on 20 January 1992, recommended (recommendation 44.3) "*that a study be carried out into how new generation aircraft can be provided with a better balance*

in the display of horizontal and vertical position data, reinforcing the latter (e.g. display of planned vertical profile, topography, safety altitudes representation), and developing the associated methods allowing the crew members to be more aware with respect to the vertical position (e.g. automatic significant altitude clearance announcements in descent before the final approach phase)".

Consequently, the BEA recommends:

- **that, in liaison with the JAA and the FAA, the DGAC modify the certification regulations so as to ensure a better balance in the presentation of horizontal and vertical position data on new generation aircraft.**

4.2

Line oriented flight training, which today means flying commercial flights under supervision, corresponds to a transitional period during which First Officers do not yet possess the aptitude of co-pilots, but assume that role. The aim is to put into practice knowledge acquired in training.

During the incident, the co-pilot on LOFT did not react as a co-pilot. He allowed the Captain instructor to act alone. He was not aware of all of the responsibilities of a co-pilot.

Consequently, the BEA recommends:

- **that the criteria for performance of flights under supervision guarantee the effective presence of an additional pilot trained in supervision.**

4.3

The investigation showed that neither the pilots nor the operator knew the number of flying hours really worked. The system for calculating flying hours did not take into account positioning. The Captain's flying hours in 1997 (see paragraph 2.4) exceeded the regulatory limits several times. The BEA considers that this point is covered by the fifth recommendation of the preliminary report mentioned above.

The investigation also showed that first officers on line oriented flight training counted the hours spent in the observer seat, which corresponds to at least 25% additional flying hours.

Consequently, the BEA recommends:

- **that AOM Minerve S.A. ensure that flights counted by pilots in training are really performed as members of the crew.**

4.4

A training flight causes a higher level of fatigue than a normal flight. Simulator training sessions are not counted as working hours. Finally, hours worked on the

ground add to flying hours in terms of fatigue. However, the regulations on flight crew work time do not take into account all of these factors.

Consequently, the BEA recommends:

- **that the regulations on flight crew work time take into account all aspects which cause fatigue.**

4.5

- The representation of the ILS heading on the HSI made it impossible for the Captain to notice the display error, which was of the order of 180°.
- Under certain circumstances, the FMA can display LOC CAP when the automatic system makes it impossible for the airplane to capture the localizer.
- The French special certification conditions relative to the capture of an ILS heading for MD83's are unclear and lack the element of compulsory application. They failed to identify a fault in the airplane which, as the investigation showed, is reproducible on the manufacturer's simulator.

Consequently, the BEA recommends:

- **that the manufacturer takes immediate steps to warn operators of MD83's that, in certain circumstances, the active modes displayed on the FMA can differ from those which the airplane is in fact engaged in at that moment.**

- **that the FAA, in liaison with the DGAC, immediately require modification of the MD83 so that the active modes displayed on the FMA indicate what the airplane is in fact doing at that moment.**

- **that the DGAC ensure that the French and European certification regulations have clear specifications concerning ILS capture.**

4.6

Another aspect of ergonomics also contributed to the mechanism of the incident. The investigation showed that the alarms produced by the CAWS and the GPWS could occur simultaneously and be superimposed on each other. During the incident, the CAWS alarms masked those of the GPWS and this situation is likely to be reproduced in other contexts. The investigation into the Mont Sainte Odile accident already identified the impact which cockpit ergonomics could have on flight safety.

Consequently, the BEA recommends:

- **that the certification requirements be modified so that certification takes into account the overall management of alarms in the cockpit;**

- **that the implementation of this recommendation, along with recommendation 44.3 in the report into the Mont Sainte Odile accident of**

20 January 1992, be made a priority by the DGAC and the JAA.

4.7

Information on flight level provided to controllers on their radar screens is not the same as that used by flight crews below the transition level, specifically the altitude.

Consequently, the BEA recommends:

- **that the DNA study the possibility of presenting controllers with vertical airplane positions expressed in altitude when an airplane is below the transition level.**

4.8

Three in-flight inspections were carried out in 1997, with only one being on an MD83. This rate was clearly inadequate, particularly when taking into account the rapid increase in the airline's activity.

Consequently, the BEA recommends:

- **that the DGAC significantly increase the number of in-flight inspections, particularly in case of a major increase in an airline's activity.**

4.9

The DAC has a limited range of actions which it can take against an airline. This leads to not systematically penalizing problems encountered or to delaying correcting them by means of successive exemptions. The objective of ensuring safety is thus not achieved.

Consequently, the BEA recommends:

- **that the DGAC establish a scaled range of penalties for problems uncovered to allow systematic, rapid and appropriate measures to be taken.**

- **that the DGAC forbid the extension of time limits set for the correction of problems identified.**

4.10

In paragraph 2.11, the ATC procedure for supplying meteorological information during approach was shown to be ill-adapted to the conditions on the day of the incident (rapid fluctuations in RVR). At the time of the morning flight, the crew should not have continued the approach after passing the OM.

Consequently, the BEA recommends:

- **that the DGAC modify the procedure for supplying meteorological information when the latter is less reliable so as to ensure that crews are informed of the exact visibility at the moment they must decide whether to continue an approach.**

4.11

A recommendation in the preliminary report dealt with the question of the conformity of the Orly approach chart. Jeppesen charts are widely used by airlines. Any errors which the charts may contain thus have a potential impact on safety. Consequently, the BEA recommends:

- **that aircraft operators ensure that documentation given to crews is valid and, where necessary, draw the crew's attention to differences or errors identified.**

4.12

None of the recording systems available made it possible to know how the crew had affected, by its actions, the vertical mode of the airplane. Consequently, the BEA, on the basis of recommendation 44.3 of the Mont Sainte Odile report, recommends:

- **that the recording of images from the cockpit instrument panel on protected recorders be required, the images being synchronized with those of other mandatory recordings.**

4.13

It was not possible to determine what the controller saw on his radar screen. This is not the first time that such a problem has been encountered during an investigation.

Consequently, the BEA recommends:

- **that the DGAC install some means of reconstituting images as seen on a radar screen.**

4.14

During readout of the QAR data, which was identical to that on the FDR, it appeared that the "Glideslope" and "Terrain" parameters did not correspond to the parameters which were really recorded, that is to say to the "Glideslope" and "Warning" lights in the cockpit. In the absence of simulations, this might have distorted a part of the analysis of the incident.

Consequently, the BEA recommends:

- **that aircraft manufacturers ensure that the denomination of parameters**

on flight recorder decoding grids correspond to the parameters really recorded.

NTSB COMMENTS

In accordance with the provisions of Annex 13 of the Convention on International Civil Aviation, the United States, as State of Design and Manufacture of the aircraft, nominated an Accredited Representative to participate in the investigation. In application of rule 6.9 of Annex 13, the draft report was sent to the Accredited Representative who, in return, provided the American comments.

The BEA took these comments into account, but this did not lead it to modify its conclusions as proposed by the Accredited Representative. The analysis showed that this serious incident was the result of a series of more or less crucial events. The BEA considered that it was appropriate, in the interests of safety, to indicate each of these events and to recommend that action be taken, whatever the relative importance of the event in the chain, without prejudging its contribution to a possible future incident or accident. The comments of the United States are thus attached in their entirety, as an appendix to this report.

National Transportation Safety Board
Washington, DC 20594 July 8, 1999

Thank you very much for the opportunity to comment on the report on the serious incident involving the Boeing Mc Donnell Douglas MD83, F-GRMC operated by AOM, on November 23, 1997 near Paris/Orly Airport. As the state of design/manufacture, the Accredited Representative United States of America and advisors participate in Annex 13 aircraft accident investigations with a primary interest in the continuing airworthiness issues of the aircraft, as well as any other aviation accident prevention issues that may improve aviation safety.

We recognize that this AOM serious incident presents unique accident prevention opportunities for the Bureau Enquetes-Accidents of France, the French DGAC, the operator, the U. S. regulators and operators and the world aviation community. This is an exclusive event in that fatalities and aircraft damage was narrowly avoided.

As the U.S. Accredited Representative, my review is intended to support the stated objective of paragraph 3.1 of Annex 13, which is to prevent accidents and incidents, not to apportion blame or liability. Further, we view any recommendations in the report to be intended for the same purpose, to avoid recurrence of any similar accident or incident.

I have discussed the report with the participants of the U.S. Accredited Representative's team and we concur with the probable cause of the accident as presented in the report, i.e., the decision to put the airplane into descent when, as a result of a display error, it was neither on the localiser track nor on the glide path, and with no context defined for this improvised maneuver. However, the U.S. Accredited Representative team does not concur with the "other contributory factor(s) - a fault in the automatic pilot system". We suggest the contributing factor would be more accurate if it stated that, "the pilot flying inserted an incorrect

inbound ILS heading for the approach and the error was not detected by the pilot not flying (monitoring pilot)".

The report provides evidence to support the conclusion that, following the pilots insertion of the incorrect ILS inbound course, the flight crew lost situational awareness and the investigation provides sufficient support that the reasons were not related to any airplane system, structure, or power plant malfunction. On the other hand, the report presents evidence that there was a lack of aircrew resource management to include insufficient understanding of any approach briefing and/or the monitoring pilot's responsibilities to communicate to the flying pilot any deviations from the normal stabilized approach parameters. There is no evidence to indicate that the crew members followed normal ILS course intercept/glide path procedures or referred to the ILS raw data display in an effort to verify flight management information. Therefore, from in airworthiness point of view, the U.S. participants do not concur with report recommendation 4.5 that "the FAA, in liaison with the DGAC, immediately require modification of the MD83 so that the active modes displayed on the FMA indicate what the airplane is in fact doing at the moment". To endorse this recommendation and justify airplane changes, one must overlook the incorrect crew actions that brought about the situation and also accept that other crews can be expected to display a similar lack of airmanship which will result in a similar series of errors. With the modern emphasis placed on crew resource management, all-crew standardization, stabilized approaches, attention to GPWS warnings and no-fault go around procedures, there is little indication that this possibility is likely to repeat itself.

Perhaps it would be worthwhile to examine the philosophy of airplane certification regulations and requirements for procedural guidance to determine if combined crew errors such as an incorrect ILS course combined with an absence of flight deck monitoring/CRM participation form an appropriate base for establishing or modifying certification criteria. If this is so, then further specifics should be presented to clarify and support the related conclusions and recommendations in the report. It would also be beneficial to provide an update on the progress of the earlier recommendations from the Mont. Saint Odile accident which are referred to in current recommendations 4.1, 4.6 and 4.12.

Regarding recommendation 4.6, we fully support your recommendation that the overall management of cockpit alarms deserves evaluation and prioritization by certification authorities to ensure that the alarms meet the intended function; and we add that any airplane modifications should be reviewed to ensure that such alarm priorities are maintained.

With best regards,

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