REPORT

Serious Incident which occurred on **20 December 2009**
In the cruise, FIR de Reims
to **Mc Donnell Douglas MD83**
registration **F-GMLU**
operated by **Blue Line**

BEA

Bureau d'Enquêtes et d'Analyses pour la Sécurité de L'aviation Civile
[Bureau of Investigation and Analysis for Civil Aviation Safety]

Ministry of Ecology, Sustainable Development, Transport and Housing

Foreword

This report sets out the conclusions of the BEA into the circumstances and the causes of this incident.

In accordance with Annex 13 to the Convention on International Civil Aviation and to Regulation (EU) No 996/2010, the investigation was not conducted with a view to apportioning blame or assessing individual or collective liability. Its sole objective is to draw lessons from this incident which might prevent future accidents.

Consequently, any use of this report for purposes other than prevention could lead to misinterpretation.

Table of Contents

Glossary

CDU	Control and Display Unit
DFGS	Digital Flight Guidance System
FCOM	Flight Crew Operations Manual
FIR	Flight Information Region
FL	Flight Level
FMA	Flight Mode Annunciator
FMS	Flight Management System
FOB	Flight Operations Bulletin
ft	Feet
GWT	Gross Weight
ISA	International Standard Atmosphere
Lbs	Pounds
MAC	Mean Aerodynamic Chord
PF	Pilot Flying
PMS	Performance Management System
PNF	Non Flying Pilot
TRP	Thrust Rating Panel
ZFW	Zero Fuel Weight

Synopsis

EVENT:

Inputting error, near stall at high altitude

Consequences and damage:
None
Aircraft:
Mc Donnell Douglas MD83
Date and time:
Monday 20 December 2009 at 1520[1]
Operator:
Blue Line
Location:
Cruising in Reims FIR
Nature of flight:
Public Transport, positioning flight
Persons on board:
6 crew members

1. PROGRESS OF THE FLIGHT

The crew was conducting a positioning flight from Paris Charles de Gaulle to Kuwait. The co-pilot was the PF.

During the flight preparations, the PF input the information into the PMS: when inputting the aircraft weight, he mistakenly entered the aircraft's zero fuel weight (ZFW) instead of its gross weight (GWT). A "CHECK GWT" error message was displayed, and he entered a weight value again. The PNF did not check the information that had been entered in the course of the pre-flight procedures and the various steps in preparation for take-off.

The aircraft took off at 14.58. During the climb the PERF CLB[2] mode was displayed on the FMA.

At 15.12, while the aircraft was levelling out at FL 260, the crew advised the Reims controller that they wished to climb to FL 370. Around one minute later, they were authorised to climb to FL 370.
At 15.14.37, as the aircraft climbed to FL 300 at a Mach speed of 0.77, the controller asked the crew whether it could reach FL 370 within four minutes, in anticipation of a crossing aircraft (see path tracks in Annex 1). Having consulted the performances in the PMS, which indicated a minimum Mach speed of 0.59, i.e. 187 knots, the crew replied that it was indeed able to comply. The PF selected a climb speed of Mach 0.65 in order to maintain a margin of safety in relation to the maximum capabilities of the aircraft.

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[1] Unless otherwise stated, the times contained in this report are expressed in Coordinated Universal Time (UTC). Add two hours to obtain the time in mainland France on the date of the event

[2] The PERF CLIMB (Autothrottle) and PERF MGMT (Autopilot, Longitudinal/Pitch control) modes are recorded.

At 15.18.09, while the aircraft was at around 2,700 ft from FL 370, the controller asked the crew to turn 20° to the left. He asked the crew of the other aircraft to do the same.

At 15.18.15, the Mach number started to decrease, reaching 0.65 Mach two minutes and ten seconds later.

At 15.19.13 the aircraft came out of the turn, and the calculated angle of attack was 3° (see Annex 2), which started to increase.

The aircraft levelled off at FL 370 at 15.19.30. The Mach number was 0.67.

At 15.20.42, the angle of attack peaked at 5.2°. The Mach number was 0.64. The ATHR mode displayed on the FMA changed to MACH ATL[3], indicating that the thrust required to maintain Mach 0.65 was greater than maximum thrust.

The crew reported that they felt buffeting and they thought that the aircraft was behind the power/speed curve. The aircraft was close to stalling speed. At 15.20.44, the pilot manually disconnected the autopilot and began a descent, banking to the left. He informed the controller that he was descending to FL 330. The angle of attack decreased to 2.5°, then increased again[4].

At 15.21.03, the angle of attack was 6.1° [5].

During the descent, the speed increased, which caused the buffeting to stop.

At 15.22.52, the crew interrupted the descent to FL 350 at Mach 0.73.

At 15.23.06, the autopilot was re-engaged. The aircraft accelerated, levelling off.

At 15.24.02, the aircraft was in level flight at FL 350 and at Mach 0.76 [6].

The flight continued without further incident.

2 ADDITIONAL INFORMATION

2.1 Description of the PMS

The PMS is a system which automatically controls pitch and thrust during the climb, cruise and descent phases in order to obtain an optimal flight profile. It bases its calculations on the input flight plan data.

The calculations are made using a set of equations related to the performance of the aircraft and the flight parameters. The PMS provides protection, in particular against excessive speed and insufficient speed.

The data are input and can be viewed at any time during the flight in order to monitor performance via the CDU screen. Each page of the screen consists of a title and three lines for inputting or displaying data or activating sub-sections using the selection keys.

[3] This mode indicates that the current Mach number is lower than the Mach number set and that the auto-throttle is currently demanding maximum thrust, displayed on the TRP.

[4] The pilot controlled the descent in order to avoid an aircraft operated by the airline Régional.

[5] The crew stated that they had only noticed that the speed was unusually low.

[6] The modes recorded are MACH and ALT HOLD.

The CDU panel

The performance (PERF) mode used is indicated on the annunciator panel of the CDU (CLB, CRZ or DES). The corresponding message on the FMA is PERF CLB, PERF CRZ or PERF DES; it appears on the autothrottle and pitch windows.

The PMS is coupled to the DFGS by pressing the PERF button on the control panel. The following requirements are in place for coupling the PMS:

- flaps at an angle of less than 26°;

- thrust indicator in neither the take-off position nor the go-around position;

- flight director or autopilot engaged;

- PMS valid (i.e. GWT, FUEL and TRIP values input);

- autothrottle engaged.

When inputting GWT and FUEL data, the "CHECK GWT" and "CHECK FUEL" error messages appear if abnormal data is entered: the GWT value must be between 88,000 and 170,000 lbs and the FUEL value must be between 8,800 and 65,000 lbs. However, the PMS does not reconcile the GWT data with the FUEL data.

The aircraft weight value input into the PMS is the GWT, whereas the value input into the fuel panel is the ZFW.

Moreover, there is no mechanism for checking consistency between the data input into the PMS (GWT and FUEL) and those input into the fuel panel (ZFW and FUEL)[7].

2.2 Buffeting and stall alarm

The airworthiness requirements applicable at the time of certification of the MD83 (FAR 25, Amendments 25-1 to 25-40, effective at 2 May 1977) imposed a 7% margin in speed between the stall and the stall warning[8]. This warning may be sounded either by the aircraft's aerodynamics or by a system which provides clearly identifiable indications in determined flight conditions.

[7] GWT = ZFW + FUEL

[8] The current airworthiness requirements impose a margin in speed of 5 knots or 5%, whichever is greater.

In the MD-80, the stick shaker is triggered to warn of an imminent stall at low altitudes. At high altitudes, the warning sign is buffeting rather than triggering of the stick shaker. The latter is triggered later, when the margin is less than 7%.

When the buffeting started, the crew noticed that the speed was low and responded appropriately by initiating a descent to regain speed.

2.3 Performance

The actual weight of the aircraft at the time of the incident is estimated as 126,500 lbs, according to the value read on the fuel management panel by the crew.

The crew reported that the meteorological conditions when the incident occurred were clear skies (SKC) and that they did not activate the de-icing systems.

The stall limit values for Mach 0.76, an ISA temperature and a weight of 126,500 lbs are:

Stall altitude	Optimum altitude	1.3 g buffeting altitude
37,000 ft	36,700 ft (interpolated value)	34,700 ft (interpolated value)

The curve of the flight field extracted from the FCOM (see Annex 3) gives the Mach numbers for the onset of buffeting of 1g, for a weight of 126,500 lbs and a centre of gravity at 23% MAC:

- Mach buffet onset low = 0.64
- Mach buffet onset high = 0.82.

Engine thrust was limited by the thrust limit displayed on the TRP and did not allow the aircraft to climb while maintaining Mach 0.65. This meant that the Mach number reduced to 0.64 and the buffeting started.

The speed, Mach and stall level information provided by the PMS during the flight were consistent with the weight input during the flight preparations.

The stall level at FL370 and the low speeds proposed by the PMS did not alert the crew due to the fact that it was a positioning flight. In fact, they thought that the plane had a lower weight, which permitted good performance.

2.4 Flight preparation

The co-pilot mistakenly input into the PMS the ZFW value of 86,520 lbs instead of the GWT value of 129,673 lbs. Since the value input was lower than 88,000 lbs, the "CHECK GWT" error message appeared. The co-pilot stated that he then re-entered the weight value and the error message disappeared. He does not remember what value was entered. The pilot -in-command did not cross-check the weights entered.

Furthermore, the indications of the flight plan gave an initial cruising level of FL 350 with an estimated take-off weight some 5,000 lbs[9] lower than the actual take-off weight. The crew might have been alerted when the PMS proposed a cruising level higher than FL 350 (FL 370) even though the aircraft was heavier.

The crew reported that the poor meteorological conditions on departure (snow on the ground) and problems with the airline's preparations had resulted in a significant delay and thus a high workload.

2.5 Procedures

Information on the inputting and verification of performance data at take-off can be found in the following documents:

- Normal procedures

- Pre-flight and transit

- Preparation for departure

- Use of systems: these procedures more specifically describe inputs into the PMS.

Information on the inputting of parameters may also be found in the departure briefing.

In line with these procedures, the data is input into the PMS in two stages. During the pre-flight phase, the PF prepares the FMS and PMS and these are checked by the PNF. When preparing for departure, upon receipt of the weight and balance report[10], the crew updates the apron weight in the PMS on the basis of the latest ZFW.

2.6 Previous events

This incident has similarities with the accident on 16 August 2005 at Machiques (Venezuela) involving a Boeing (McDonnell Douglas) DC-9-82 (MD-82) registration HK-4374X operated by West Caribbean Airways.

The report published by the Venezuelan investigation authority (the JIAAC), available on the BEA website[11], indicates that the aircraft was behind the power/speed curve following failures in the supervision of the flight performance parameters. The crew did not correctly identify the imminent stall. The aircraft then stalled and the crew was unable to regain control of the aircraft.

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[9] The FPL GWT was 124,699 lbs, whereas the GWT input by the crew was 129,673 lbs.

[10] Upon receipt of the weight and balance report, the crew did not update the weights because the ZFW was not different.

[11] [the original report has a link to a French language report and there is no official English language translation, but see http://www.skybrary.aero/index.php/MD82,_En_route,_near_Machiques_Venezuela,_2005_(LOC_HF)where there is access to an unofficial summary translation].

This report contains at annex a NASA study on incidents involving high-altitude stalls for the aircraft of the MD-80 type. Following a mid-air incident with an MD-80, the manufacturer published an updated FOB No. MD-80-02-02-02A on 6 August 2002. This document (available in Annex 4), sent to the crews and operational services of airlines operating MD-80 type aircraft, issued a reminder of the characteristics of the autopilot and autothrottle systems of the MD-80 aircraft and highlighted peculiarities in the way they functioned.

In the reference to the event covered by the FOB, it is indicated that the aircraft involved in the incident could no longer maintain airspeed when at its cruising altitude. After a period of about five minutes, the air speed of the aircraft began to decrease, eventually activating the stick shaker and triggering the voice alarm warning the crew of a stall. In this bulletin, one of the points made by the manufacturer is the following: *"When the auto-throttle is in (maintain) speed mode and the autopilot is in (maintain) altitude mode and the thrust required to maintain the flight level is greater than the thrust available, the aircraft may lose speed until the stall alarm is triggered prior to disconnection of the autopilot."*

Certain safety recommendations of the Venezuelan authority concern raising aircraft crew awareness of the limitations of the aircraft flight field so that they can avoid such high-altitude near-stall situations. The JIAAC also recommends including the FOB content in flight manuals and skill maintenance programmes and enhancing the content of training to raise the awareness of flight crews of the implications of buffeting at high altitude.

3 - CONCLUSION

The incident, involving a near stall, was brought about by an error inputting the weight into the PMS.

Corrective action

Following notification of the incident, the BEA sent the airline their [Use of incorrect parameters on take-off] study[12] .

The operator issued internal recommendations concerning:

- the verification in the assessment of competencies of knowledge of the magnitude of operational values;
- the introduction into a CRM module of the specific consequences of charter flights;
- the introduction into a CRM module of the importance of briefings and cross-checks;
- a reminder of the need to fill the card out again if the actual weight is more than 3 tons greater than the expected weight entered during flight the preparations;
- the changes to the procedures for improving the identification of cross-checks.

[12] English version at http://www.skybrary.aero/bookshelf/books/668.pdf

LIST OF ANNEXES

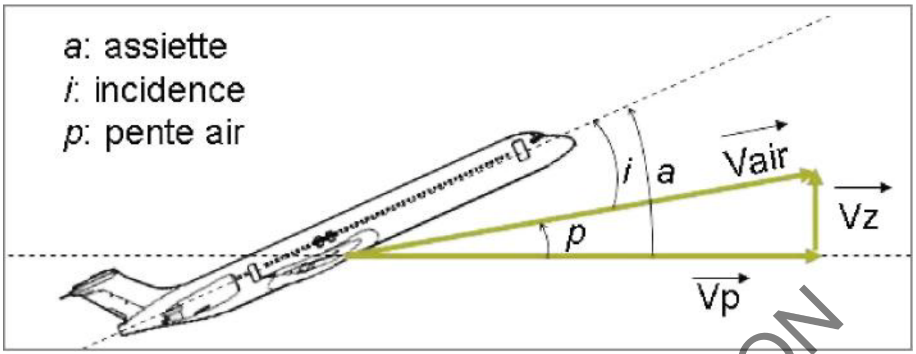
ANNEX 1
TRACK

The radar tracks for the F-GMLU and the other aircraft have been calculated on the basis of the raw data from the Grand Ballon radar. At 15.21, the two aircraft were some 15 NM to the north of the town of Vittel.

ANNEX 2

CALCULATION OF ANGLE OF ATTACK

The angle of attack can be calculated on the basis of the following recorded parameters: altitude, CAS , pitch, TAT and Mach number.



Parameter a (*assiette*) is the pitch.

Parameter p (*pente air*) is equal to arcsine (Vz/Vair).

Vertical speed (Vz) is calculated on the basis of the altitude parameter, smoothing the values over 5 seconds.

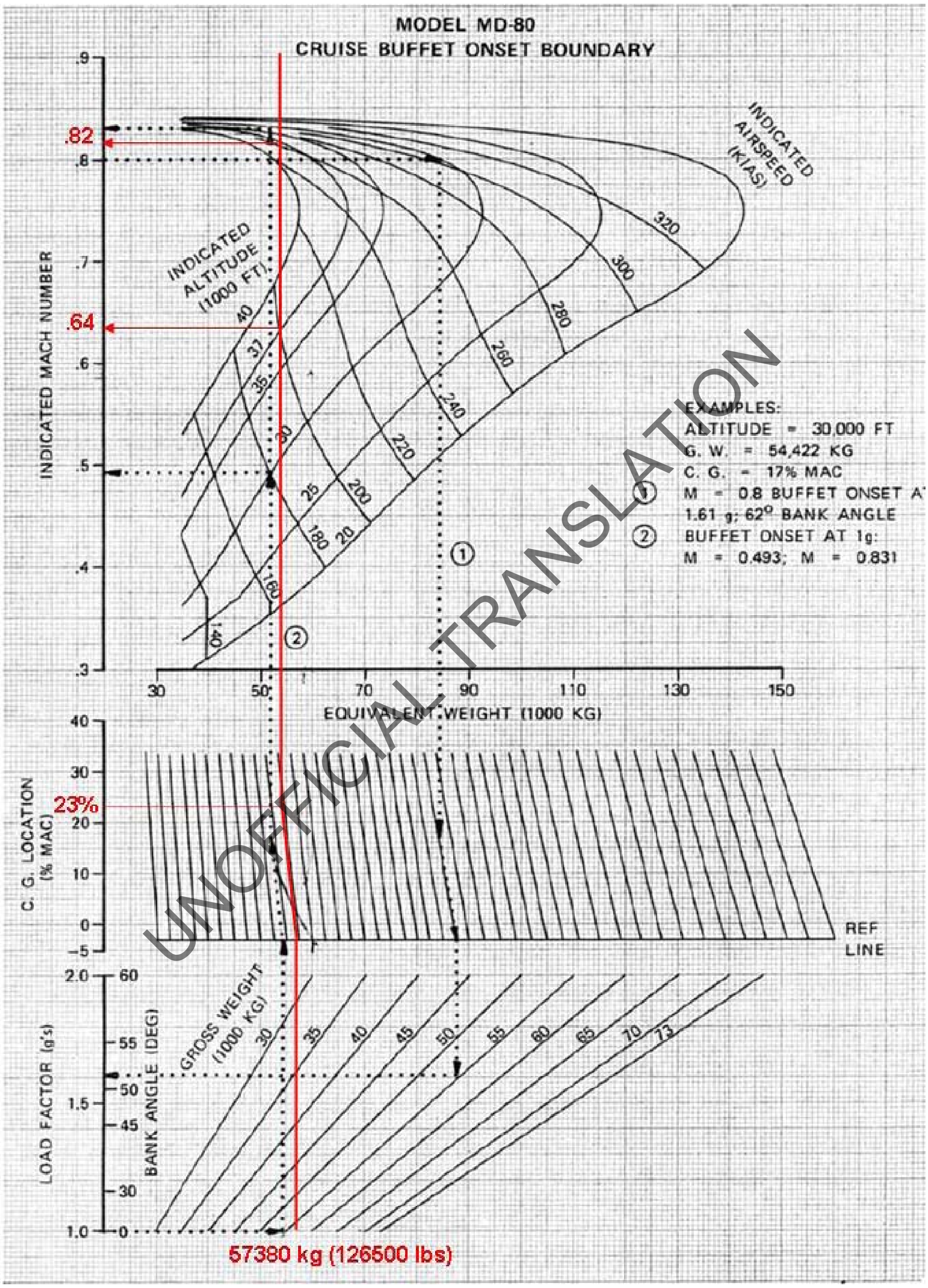
The airspeed (Vair) is calculated using the static air temperature (SAT), the CAS and the altitude.

SAT is calculated from the TAT total air temperature and the Mach Number.

This gives us the angle of attack i = a – p.

ANNEX 3

FLIGHT ENVELOPE AT FL 370



ANNEX 4
FOB

F O B
FLIGHT OPERATIONS BULLETIN

FLIGHT OPERATIONS

Boeing Long Beach

August 6, 2002
ATA: 22-00, Autoflight
Bulletin No. MD-80-02-02A

Applicable to: *All MD-80 Aircraft*

Subject: DESCRIPTION OF THE MD-80 AUTOPILOT MODES

On July 19, 2002, Long Beach Flight Operations issued Flight Operations Bulletin MD-80-02-02. This bulletin is a re-issue of the same with a deletion. Please destroy Bulletin MD-80-02-02 and replace it with MD-80-02-02A.

Boeing LBD is issuing this bulletin as a result of a recent MD-80 incident. The incident occurred after the subject aircraft was unable to maintain cruise airspeed, while level at cruise altitude. Over a period of some five or more minutes, the airspeed decayed to the point that stick-shaker was activated, and the STALL aural warning was annunciated. During the entire period of airspeed decay, the autopilot maintained the commanded cruise altitude. The intent of this bulletin is to examine the characteristics of the MD-80 autopilot system, as they pertain to this occurrence.

The MD-80 autopilot/autothrottle system operates in two basic modes, Speed on Thrust (SOT) or Speed on Pitch (SOP). When in the Speed on Thrust mode, elevator commands are used to control to a vertical flight path - either Altitude Hold or Vertical Speed, while the auto throttles adjust power to maintain the selected airspeed. In the Speed on Pitch mode, the elevator commands are used to maintain the selected airspeed, while the autothrottles will normally go to idle or the thrust limit and remain fixed.

While in the Speed on Thrust mode, pilots must monitor the selected airspeed to ensure that the thrust available is sufficient to control speed. For example, if too high a vertical speed is selected in descent, the airplane will overspeed since the throttle can only retard to idle thrust. Similarly, if too high a vertical speed is selected in climb, the airplane could decelerate into a stall warning before the autopilot trips off. The thrust available may be insufficient to maintain the selected airspeed even at the thrust limit.

Flight Operations, Boeing Long Beach, 3855 Lakewood Boulevard, M/C: (D041-0055)
Long Beach, CA 90846-0001, USA/Phone: (562) 593-1249/Fax: 593-3471

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However, the autopilot will command the elevator to maintain the commanded vertical speed, which requires higher pitch attitudes as the True Airspeed drops. The situation is even subtler when in Altitude Hold. If the thrust required to maintain level flight is greater than the thrust available, the airplane could decelerate to stall warning before the autopilot disconnects. In the Speed on Thrust mode, the autopilot elevator commands will not attempt to maintain airspeed.

In "Altitude Hold", airspeed decay might occur during operations at, or near, the maximum cruise altitude for the existing conditions. If the aircraft is heavier than the load sheet indicates, then the aircraft may be too heavy for that altitude, and the thrust required may be greater than the thrust available, and airspeed decay will occur. Remember, under some conditions airspeed could decay to stall warning before the autopilot disconnects. Significant changes in the ambient conditions could also result in situations where the thrust available is insufficient to maintain speed in level flight.

Conversely, in the Speed on Pitch mode, the auto throttles do not provide any speed control. Speed is maintained with pitch. Therefore, if the pilot is manually flying in the Speed on Pitch mode, caution must be used to follow the flight director or speed variations will occur.

Should additional information be required, please submit your inquiries through your local field service representative or to Boeing Long Beach, ATTN: Flight Operations Customer Service, 3855 Lakewood Boulevard, Mail Code: D041-0055, Long Beach, California 90846-0001, USA, fax: (562) 593-3471.

H. K. Sieglinger
Chief Pilot - Flight Technical Services
Long Beach Flight Operations

TJM/HKS:csl

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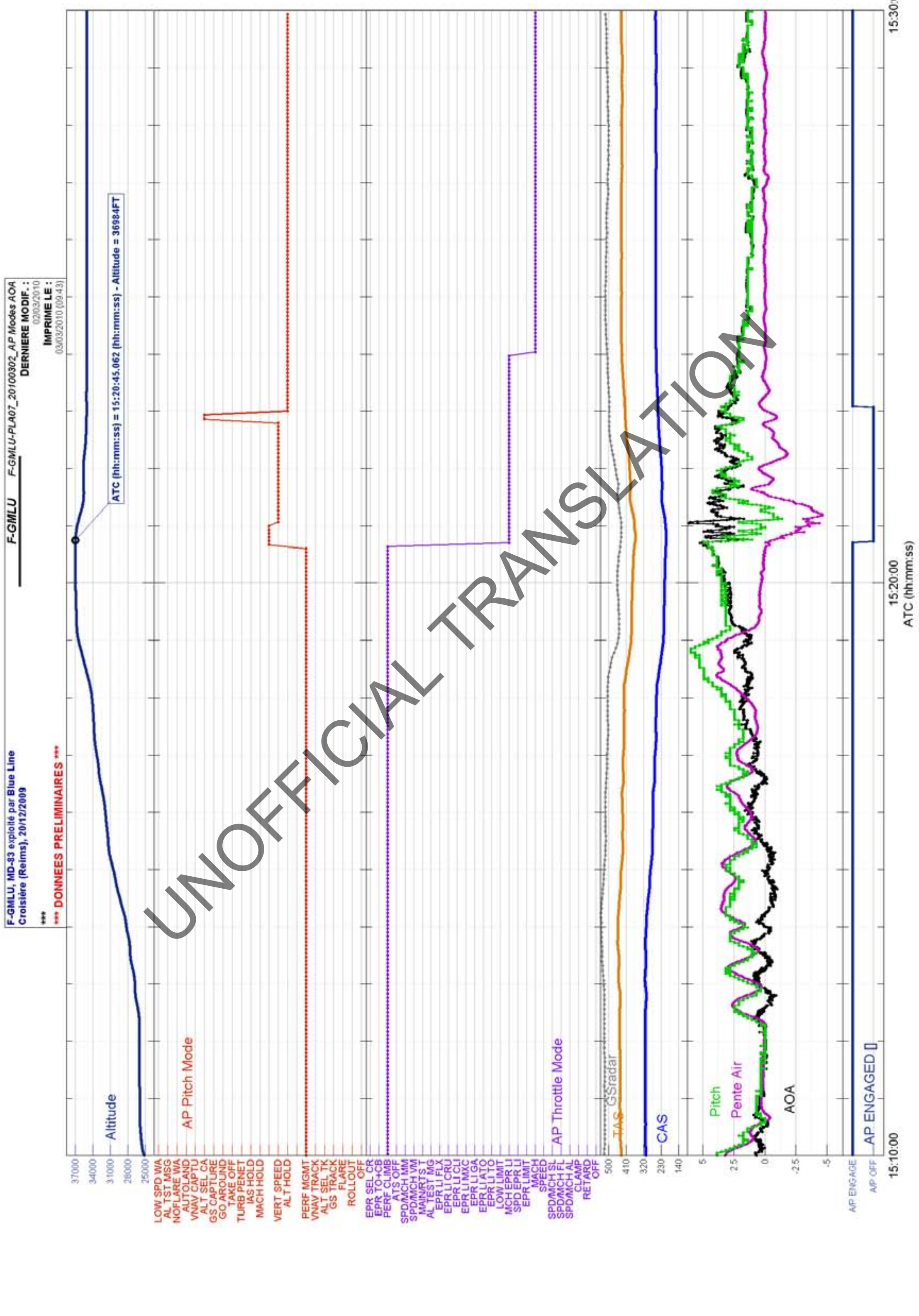
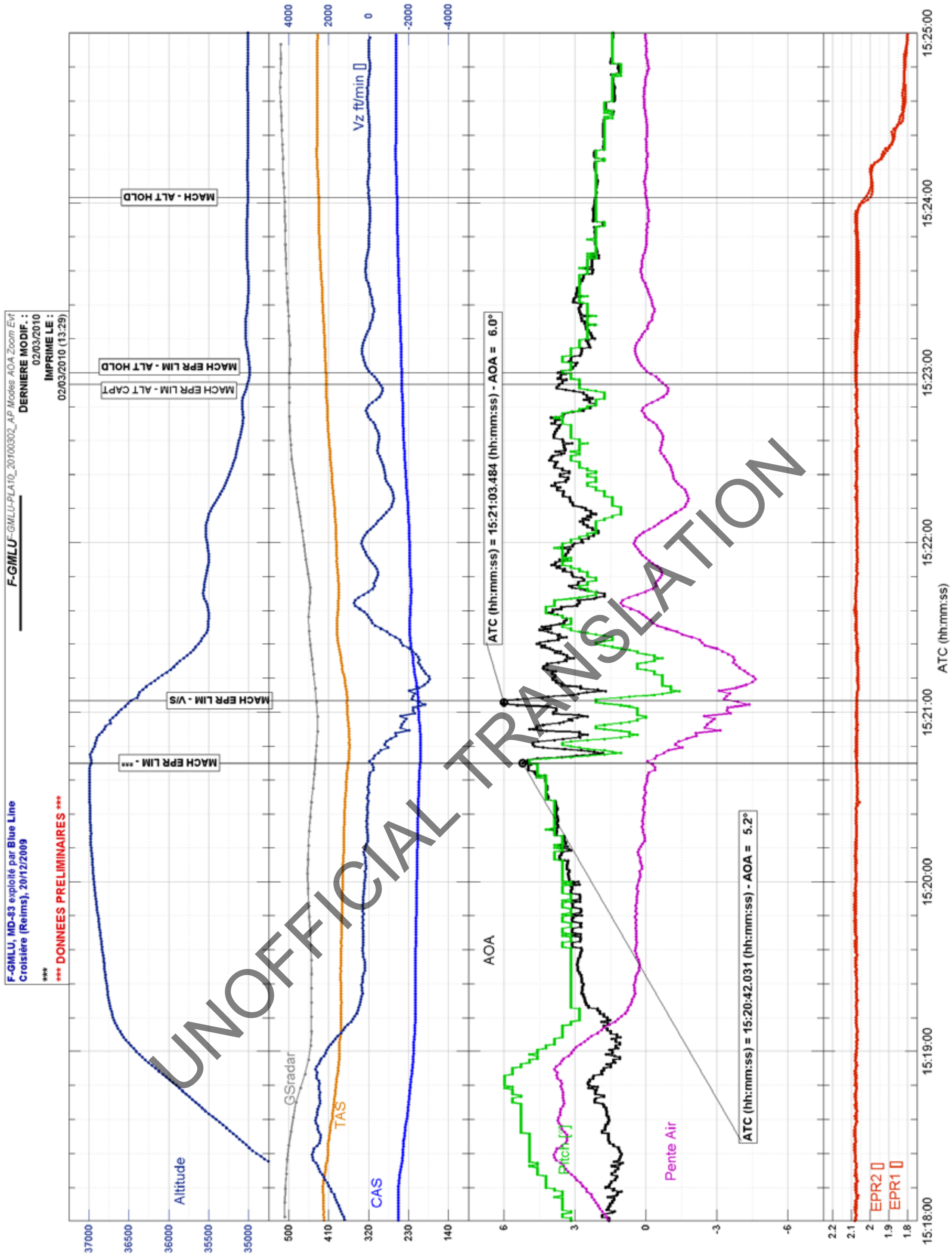
ANNEX 5
QAR GRAPHS




F-GMLU, MD-83 exploité par Blue Line
Croisière (Reims), 20/12/2009
*** DONNEES PRELIMINAIRES ***
F-GMLU
DERNIERE MODIF. :
02/03/2010
IMPRIME LE :
02/03/2010 (13:29)
MACH EPR LIM - ***
MACH EPR LIM - V/S
MACH EPR LIM - ALT CAPT
MACH EPR LIM - ALT HOLD
MACH - ALT HOLD
ATC (hh:mm:ss) = 15:21:03.484 (hh:mm:ss) - AOA = 6.0°
ATC (hh:mm:ss) = 15:20:42.031 (hh:mm:ss) - AOA = 5.2°
Altitude
GSradar
TAS
CAS
Vz ft/min
AOA
Pitch
Pente Air
EPR2
EPR1
ATC (hh:mm:ss)

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