KÖZLEKEDÉSBIZTONSÁGI SZERVEZET

FINAL REPORT

2010-202-4P
INCIDENT

Budapest-Ferihegy
20.09.2010.

BOEING 737-600
HA-LOE

The sole objective of the technical investigation is to reveal the causes and circumstances of aviation accidents, incidents or irregularities and to initiate the necessary technical measures and make recommendations in order to prevent similar cases in the future. It is not the purpose of this activity to apportion blame or liability.

This present investigation was carried out on the basis of

- Act XCVII of 1995 on aviation,
- Annex 13 of MTCW (Ministry of Transport, Communications and Water) Decree 20/1997. (X. 21.) on the declaration of the annexes of the Convention on International Civil Aviation signed in Chicago on 7th December 1944,
- Act CLXXXIV of 2005 on the technical investigation of aviation, railway and marine accidents and incidents (hereinafter referred to as Kbvt.),
- MET Decree 123/2005 (XII. 29.) on the regulations of the technical investigation of aviation accidents, incidents and irregularities,
- In absence of other related regulation of the Kbvt., the Transportation Safety Bureau of Hungary carried out the investigation in accordance with Act CXL of 2004 on the general rules of administrative authority procedure and service,
- The Kbvt. and the MET Decree 123/2005 (XII. 29.) jointly serve the compliance with the following EU acts:
    a) Council Directive 94/56/EC of 21 November 1994 establishing the fundamental principles governing the investigation of civil aviation accidents and incidents, with the exception of its Annex;
    b) Directive 2003/42/EC of the European Parliament and of the Council of 13 June 2003 on occurrence reporting in civil aviation, with the exception of its Annex I and Annex II.

The competence of the Transportation Safety Bureau of Hungary is based on the Kbvt. until 31st December 2006 and on Government Decree 278/2006 (XII. 23.) from 1st January 2007 respectively.

Under the aforementioned regulations

- The Transportation Safety Bureau of Hungary shall investigate aviation accidents and serious aviation incidents.
- The Transportation Safety Bureau of Hungary may investigate aviation incidents and irregularities which - in its judgement - would have resulted in accidents in other circumstances.
- The technical investigation is independent of any administrative, infringement or criminal procedures.
- In addition to the aforementioned laws, the ICAO DOC 9756 and DOC 6920 (Manual of Aircraft Accident Investigation) are applicable.
- This present Final Report shall not be binding, nor shall an appeal be lodged against it.

Persons participating in the technical investigation did not act as experts in other procedures concerning the same case and shall not do so in the future.

The IC shall safe keep the data having come to their knowledge in the course of the technical investigation. Furthermore the IC shall not be obliged to make the data – regarding which the owner of the data could have refused the disclosure of the data pursuant to the relevant act – available to other authorities.

SYNOPSIS

Occurrence category		incident
Aircraft	class	fixed wing aircraft
	manufacturer	The Boeing Co.
	type	737-600
	registration	HA-LOE
	operator	Malév Ltd.
Occurrence	date and time (LT)	20.09.2010. 13:00
	location	Budapest-Ferihegy

The aircraft was not damaged in the occurrence.

Reports and notifications

The occurrence was reported to the duty services of TSB by the duty officer of MALÉV Flight Safety Office at 13:37 on 20 September 2010.

Investigating committee

The Director-General of TSB appointed the following Investigating Committee (hereinafter referred to as IC) on 22 September 2010:

Investigator-in-Charge	György HÁY	accident investigator
member	László PÁL	accident investigator
member	Szilárd SÁRKÖZI	meteorologist expert

Summary of the investigation

Shortly after the reporting of the occurrence TSB delegated the investigation to the operator. Two days later, however, TSB decided to take back the investigation based on the evaluation of additional information that became available and the importance of the occurrence.

Comments to the Draft Report provided by NTSB and Boeing were incorporated into the Final Report.

Short summary of the occurrence

The aircraft was scheduled for a flight from Budapest to Helsinki as flight MAH 742. During take-off run at a speed of 107.5 kts the pilots decided to abort the take-off because they noticed a sudden lateral acceleration – jolt - of unknown origin. The aircraft returned to the apron, and the passengers were taken to another aircraft. At the time of the jolt, the FDR recorded an unusual and sudden change in airspeed coincident with movement of the two angle-of-attack vanes on the sides of the fuselage in opposite directions. This fact hints the presence of an atmospheric disturbance external to the airplane like a wake vortex or turbulence. The actual meteorology data showed that the turbulence could not be originated from weather phenomenon. One minute and 50 seconds prior to the subject take-off another B737 aircraft took off from the same runway. It is possible that the turbulence registered by the angle-of-attack vanes was in fact wake turbulence from the previous aircraft.

1. FACTUAL INFORMATION

1.1 History of the flight

The aircraft was scheduled for a flight from Budapest to Helsinki as flight MAH 742. During take-off run at a speed of 107.5 kts on runway 31L the Captain decided to abort the take-off due to a lateral jolt of unknown origin. The aircraft left the runway through taxiway B2 and returned to the apron No.79 where the passengers were asked to disembark.

1.2 Injuries to persons

There were 2 pilots, 3 flight attendants and 71 passengers aboard. There was no injury.

1.3 Aircraft damage

The aircraft was not damaged.

1.4 Other damage

None.

1.5 Personnel data

1.5.1 Pilot-In-Command

Age, citizenship, gender		51, Hungarian, male
Licence data	**type**	ATPL
	valid until	31.12.2010.
	medical check valid until	26.03.2011.
	licence	B737 commander
	ratings	CATIII/A
Total flight hours / number of take-offs	**total**	9 841 hrs
	in the last 90 days	231:55
	in the last 7 days	12:44
	in the last 24 hrs	2:14
	total on the given type	4 517 hrs

1.5.2 First Officer

Age, citizenship, gender		40, Hungarian, male
Licence data	**type**	ATPL
	valid until	31.01.2011.
	medical check valid until	09.07.2011.
	licence	B737 First Officer
	ratings	CATIII/A
Total flight hours / number of take-offs	**total**	5 859 hrs
	in the last 90 days	238:21
	in the last 7 days	22:10
	in the last 24 hrs	3:17
	total on the given type	4 558 hrs

1.6 Aircraft data

1.6.1 General

Class	fixed wing aircraft
Manufacturer	The Boeing Co.
Type	737-600
Date of manufacturing	2007
Serial number	28260
Registration	HA-LOE
State of registry	Republic of Hungary
Owner	International Lease Finance Co.
Operator	Malév Zrt.
Call sign	MAH742

1.6.2 Airworthiness

Certificate of airworthiness	**serial number**	4435
	date of issue	11.10.2007.
	valid until	9.10.2010.
	last review date	9.10.2009.
	restrictions	none

1.6.1.5 Mass and loading

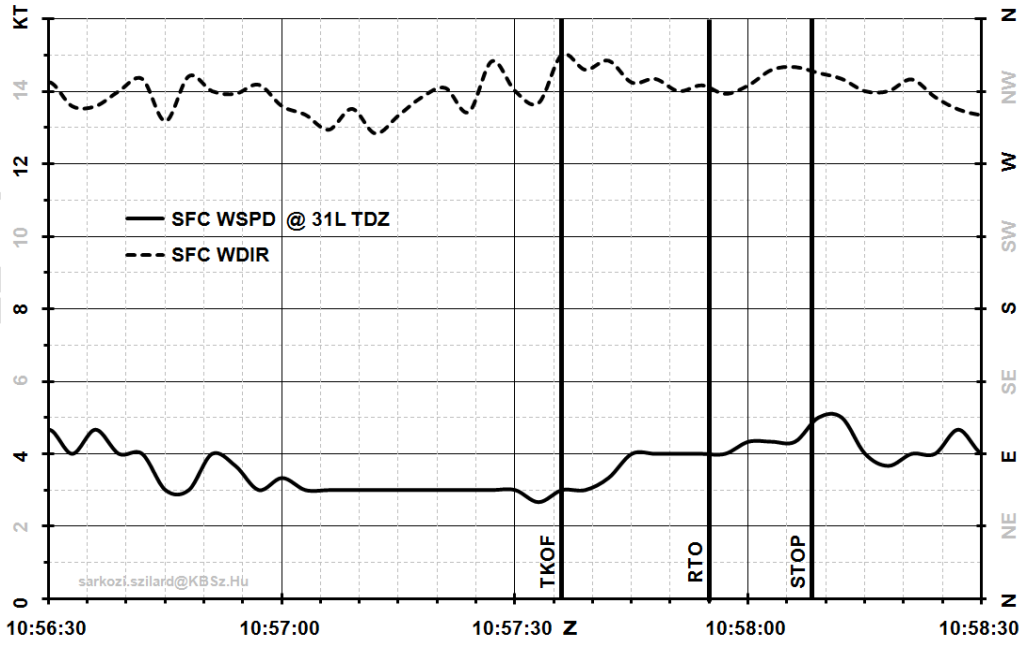
Empty mass		38 013 kg
Fuel mass		6 750 kg
Payload		6 523 kg
Take-off mass		51 286 kg
Flight mass at the time of occurrence		51 286 kg
MTOM		58 327 kg
Maximum landing mass		54 657 kg
CG position at take-off	27,93	index
CG position at the time of occurrence	27,93	index
CG range	14,08…31,58	index

1.6.2 Description of the affected system

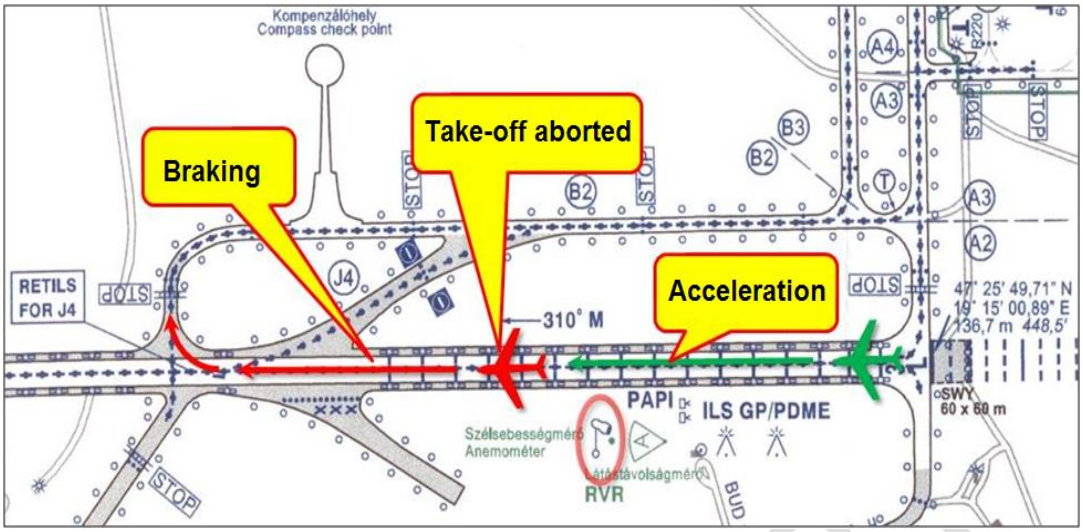
A schematic drawing of rudder control system of the aircraft can be found in Appendix 5. The rudder is controlled by the pedals and the automatic yaw-damper system. Any of these controls can independently move the rudder surface. If the two controls work in the same direction, their effect is summarised. The functioning of the yaw-damper does not have any effect on the pedals therefore its operation cannot be noticed directly by the pilots.

1.7 Meteorological information

The occurrence took place at daylight in good visibility, with no mentionable weather phenomena present. There was only fair wind, 3-5 kts, including gusts, from NW, smooth, which was ideal for take-off from 31L. Just prior to the take-off a 3-knot wind was registered from NW-NNW. (A slight turbulence of 5 kts could easily be a wake turbulence from the previous aircraft.) It is almost certain that there was no turbulence stronger that the usual daytime thermals present which could have substantial effect on the take-off.



Wind parametres recorded at a place 130 m away from the location of the occurrence



The location of the occurrence. The anemometer marked with a red circle

1.8 Aids to navigation

The characteristics of the navigation instruments had no effect on the course of events therefore their analysis was not required.

1.9 Communications

The characteristics of the communications instruments had no effect on the course of events therefore their analysis was not required.

1.10 Aerodrome information

The airport (that has been renamed Budapest Liszt Ferenc International Airport since the occurrence) had a valid operational licence. One minute and 50 seconds prior to the subject take-off another B737 aircraft took off from the same (31L) runway, starting the take-off run at taxiway A2.

1.11 Data recorders

The FDR functioned as expected. The evaluation of FDR data was conducted by the MALÉV Flight Safety Office and the Boeing Customer Support. The data showed that the engines, the aerodynamic and wheel brakes worked in full symmetry (see Appendix 2). Prior to the abort there was a lateral jolt of 0.16 g to the right while at the same time the rudder was in the position of 7.6 degrees to the left. Also at this moment the yaw-damper moved the rudder 3 degrees to left (with its maximum movement) while the pilots added an extra 2.6 degrees of pedal which equates to about 5-6 degrees of rudder. The yaw-damper then responded to the change in yaw rate and moved to its full right position of 3 degrees while the recorded acceleration shifted to 0.08 g to the left in 2 seconds. The recorded headings paired with the acceleration values were 311 degrees and 307 degrees accordingly. The data showed that after these lateral acceleration and heading changes the yaw-damper made oscillations inversely proportional to the yaw rate (per design) that slowly diminished (see Appendix 4). At the moment of the first lateral jolt the indicated airspeed stagnated while the angle-of-attack vanes registered values of opposite direction (see Appendix 3).

1.12 Wreckage and impact information

There was no wreckage.

1.13 Medical and pathological information

There are no indications of psycho-physical or other factors that could have affected the ability of the crew to flight the aircraft.

1.14 Fire

There was no fire.

1.15 Survival aspects

There was no injury.

1.16 Tests and research

The troubleshooting of the rudder system was conducted by ACE in Budapest. The work was documented on Job Order No.10LMM0112. No deficiencies were found. The operator forwarded the downloaded FDR data to the Boeing Customer Support. In their response, Boeing sent the operator the following evaluation:

- The yaw-damper activation was most probably caused by atmospheric disturbance.
- Atmospheric disturbance has been identified as the cause for the majority of reported uncommanded yaw events in the last 5 years.
- Based on the statistics Boeing does not recommend any modifications or operational limitations for B737 aircraft.

1.17 Organisational and management information

The organisational characteristics of the companies concerned had no effect on the course of events.

The relevant rules for general separation between two aircraft belonging to the same wake turbulence category do not require additional separation due to atmospheric disturbance.

The minimum separation between two departing aircraft was not breached during take-off.

1.18 Additional information

The ACE notified the Boeing Customer Support on the occurrence. Boeing analysed the FDR data and in their reply gave an evaluation, according to which the uncommanded yaw event may have been caused either by atmospheric disturbance or wake turbulence from another aircraft.

1.19 Useful or effective investigation techniques

The investigation did not require techniques differing from the traditional approach.

2. ANALYSIS

The stagnation of indicated airspeed during take-off as well as the crossing of angle-of-attack vanes one another on the fuselage sides are indicative of an encounter with atmospheric disturbance. It is highly unlikely that such a turbulence is a result of atmospheric disturbances as the air mass was calm at that time. It is more likely that the disturbance was wake turbulence from another B737 aircraft that took off just one minutes and 50 seconds prior to the occurrence aircraft.

Wake turbulence (illustration)

The pilots kept the aircraft on the centerline with the usual gentle pedal movements of a few degrees during take-off run. The unexpected acceleration spike of 0.16 g to the right could not be caused by the asymmetric work of the engines, the aerodynamic brakes or the wheel brakes because FDR data show they worked in full symmetry. At the time of the first acceleration spike the rudder moved 7.6 degrees to the left. It is most likely that this movement was a result of the yaw-damper-originated 3 degree-move (to the left) and a pilot-originated 2.6 degree steering command (also to the left).

As the Stall Management Yaw Damper Computer input parametres – speed and angle of attack in particular - were disturbed by the sudden turbulence, it cannot be excluded that indirectly this turbulence caused the extreme left-then-right movement of the yaw-damper.

At speeds around 100 kts such rudder movement generates a substantial turning momentum. As a result, the longitudinal axis of the aircraft shifted 4 degrees to the left in just more than 1 seconds while the lateral acceleration changed from 0.16 g to right to 0.08 g to the left.

In such circumstances where the aircraft's response to a rudder pedal was excessive it is fully understandable that the pilots thought the aircraft was getting uncontrollable. Due to high speed (close to V1) there was no time to analyse the situation. Aborting the take-off indisputably was the best decision in order to protect the safety of the passengers, the crew and the aircraft.

3. CONCLUSIONS

3.1 Facts

The pilots disposed of the necessary certificates, ratings, and experience to carry out the flight. During the flight they obeyed the regulations.

The aircraft was airworthy and had a valid certificate of airworthiness.

The aircraft's mass and centre of gravity were within the allowed limits.

The characteristics of the airport and the ground crew had no effect on the course of the events.

The Captain aborted the take-off at indicated airspeed of 107.5 kts.

Prior to the abort a lateral acceleration of 0.16 g rapidly shifted to 0.08 g of opposite direction.

Discrepancies in the operation of engines and/or brakes can be excluded from the possible causes of above lateral jolt.

At the time of lateral jolt, the crew input and yaw damper combined to move the rudder to a position of 7.6 degrees to the left to counter the jolt.

The pedal input at this moment was 2.6 degrees of pedal which equates to 5-6 degrees of rudder to the left. Yaw-damper input was 3 degrees (maximum) to the left, then responded to the change in yaw rate and moved to 3 degrees (maximum) to the right.

At the moment of jolt the aircraft may have encountered an atmospheric disturbance.

It is likely that the above disturbance was a wake turbulence from another aircraft that took off earlier. The take-off separation was not breached.

3.2 Causes of the occurrence

The IC has come to a conclusion that the occurrence was most likely caused by a wake turbulence from another B737 aircraft that took off from the same runway 1 minutes and 50 seconds prior to the occurrence aircraft. The yaw-damper, responded to the turbulence, made quick consecutive movements to end stop positions. The pilots successfully controlled the airplane through the jolt using rudder pedals, but decided to abort the take-off because of the unexpected acceleration of unknown origin.

4. SAFETY RECOMMENDATION

There was no need to issue a safety recommendation.

Budapest, …… Nov 2012

György HÁY
IIC

László PÁL
IC member

Szilárd SÁRKÖZI
IC member

NOTE:
This present document is the translation of the Hungarian version of the Final Report.
Although efforts have been made to translate it as accurately as possible, discrepancies may occur.
In this case, the Hungarian is the authentic, official version.

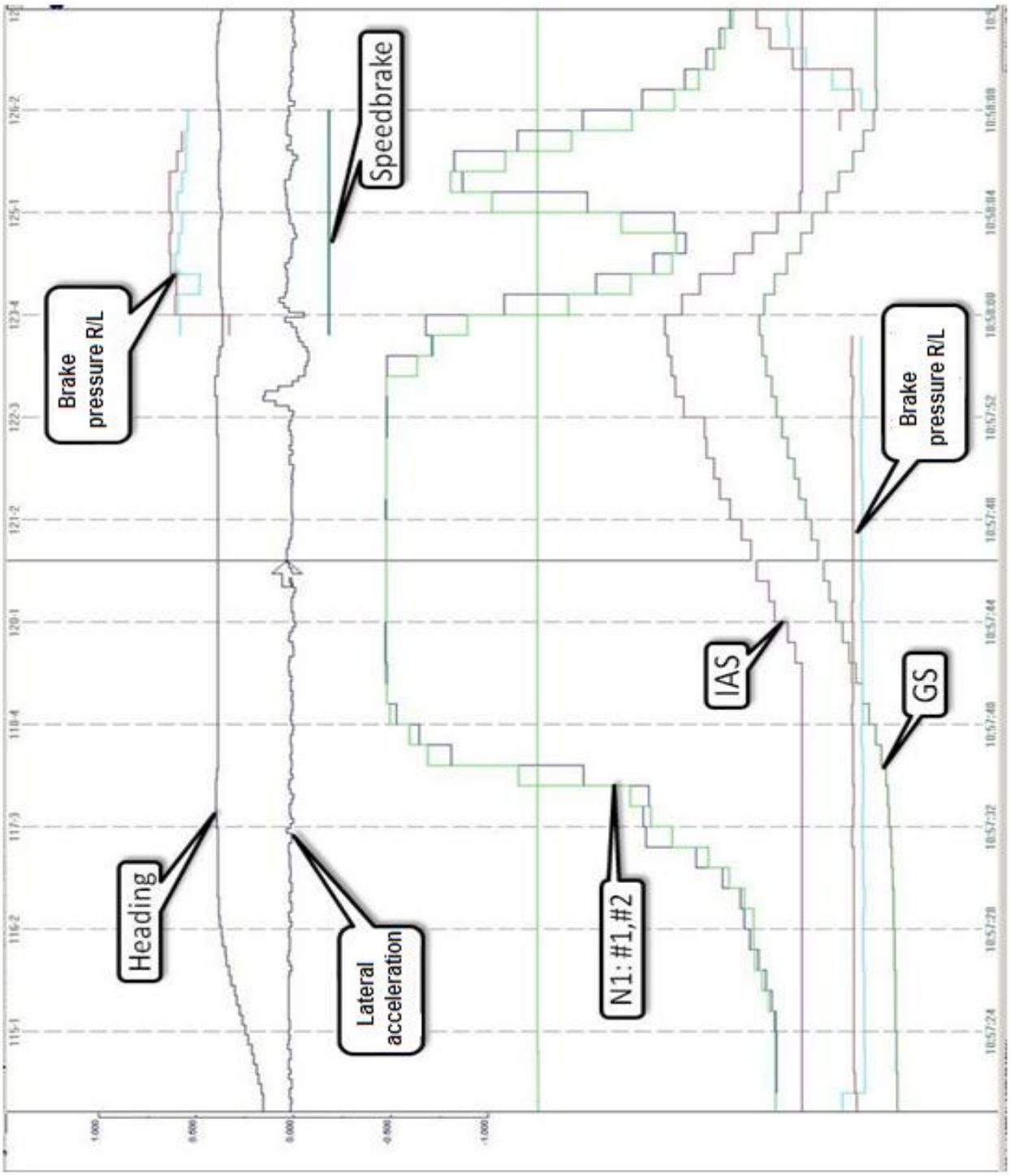
Appendices

1. Definitions and abbreviations
2. FDR information (1) Malév Zrt.
3. FDR information (2) Boeing Co.
4. FDR information (3) Malév Zrt.
5. General schematics of rudder control (737NG AMM)
6. BOEING opinion
7. NTSB opinion

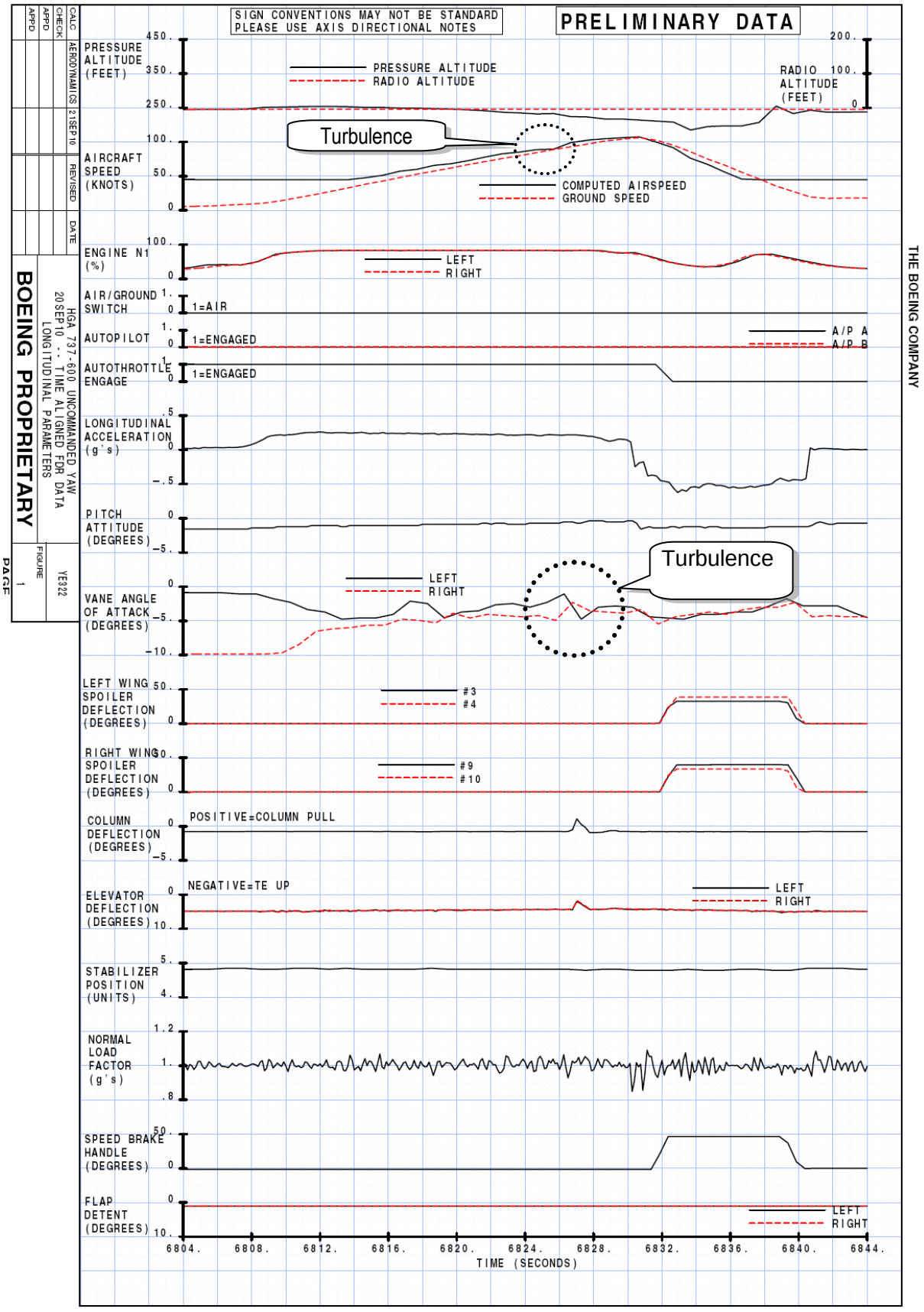
APPENDIX 1: DEFINITIONS AND ABBREVIATIONS

ACE	Aeroplex of Central Europe
ATPL	Airliner Transport Pilot Licence
Co.	Company
FAA	Federal Aviation Administration (USA)
FDAU	Flight Data Acquisition Unit
FSEU	Flap Slat Electronic Unit
MET	Ministry of Economy and Transport
GS	Ground Speed
IAS	Indicated Air Speed
ICAO	International Civil Aviation Organization
TSB	Transportation Safety Bureau
Kbvt.	Act CLXXXIV of 2005 on the technical investigation of aviation, railway and marine accidents and incidents, A légi-, a vasúti és a víziközlekedési balesetek és egyéb közlekedési események szakmai vizsgálatáról szóló 2005. évi CLXXXIV. törvény
KT(S)	Knot(s)
N1	Turbine engine low pressure rotor revolution (per minute)
PCU	Power Control Unit
RTO	Rejected Take-off
SMYD	Stall Management Yaw Damper
TDZ	Touch Down Zone
TKOF	Take-off
IC	Investigating Committee
WDIR	Wind Direction
WSPD	Wind Speed

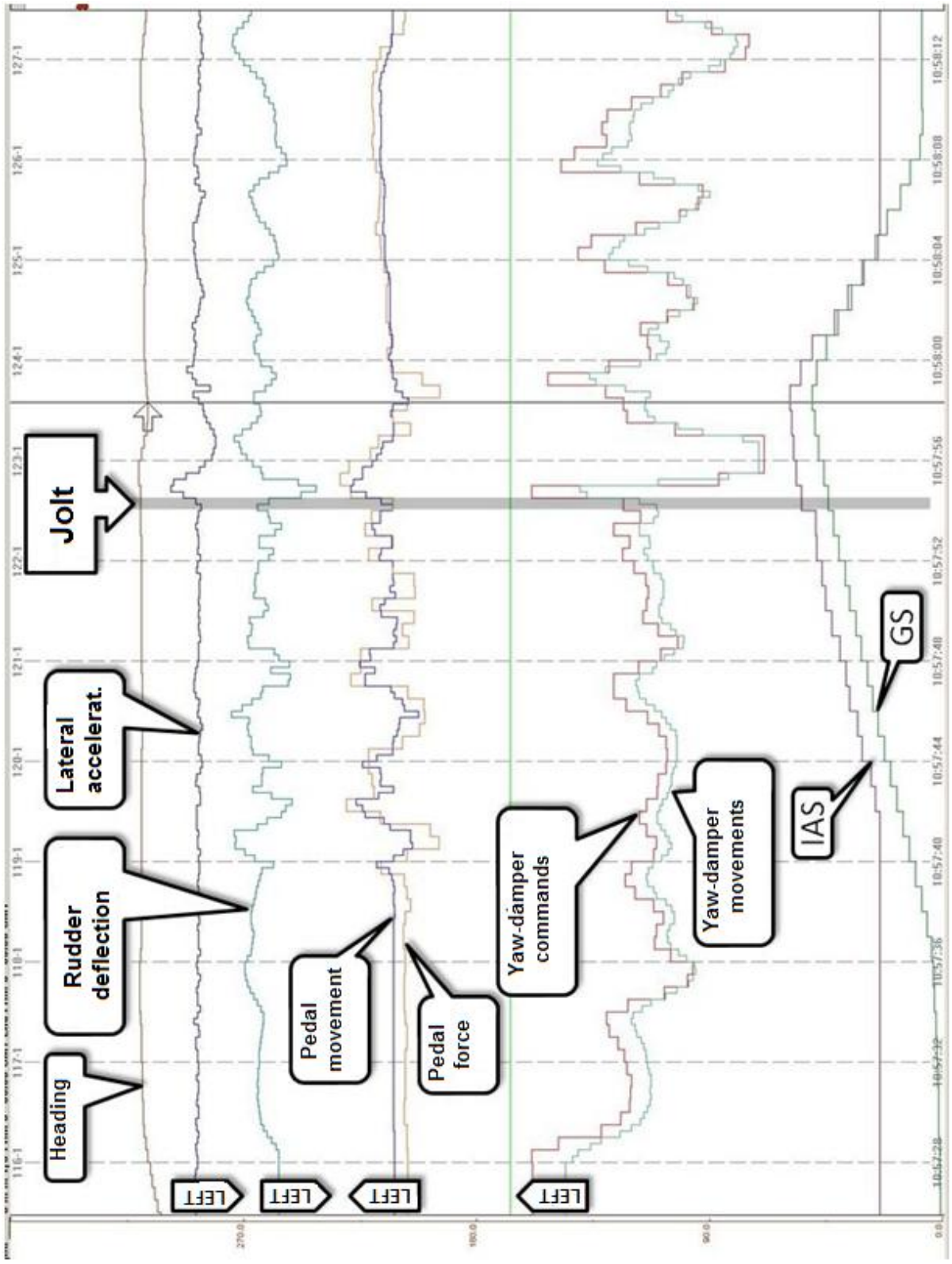
APPENDIX 2: FDR INFORMATION (1)



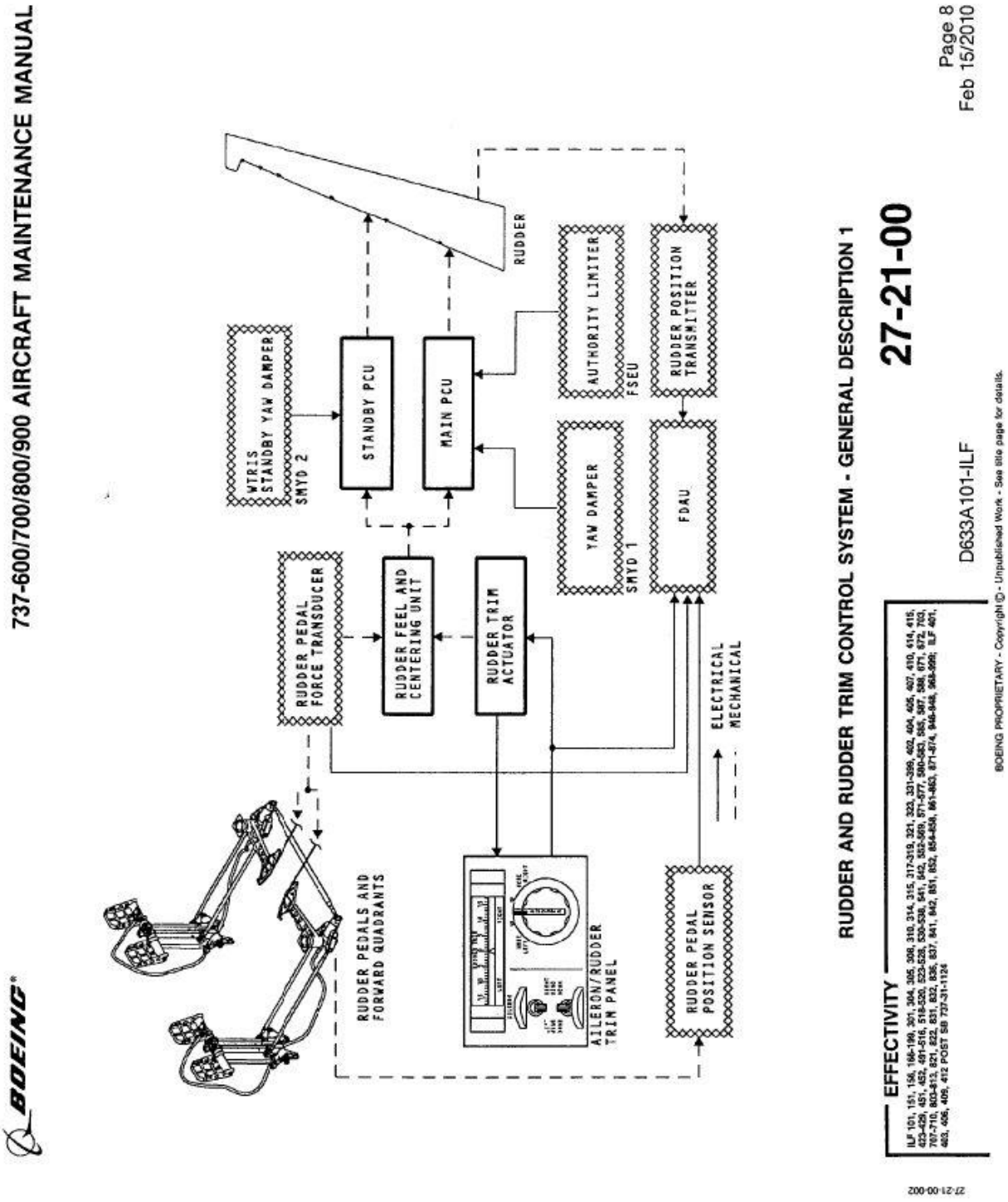
APPENDIX 3: FDR INFORMATION (2)



APPENDIX 4: FDR INFORMATION (3)



APPENDIX 5: General schematics of rudder control



APPENDIX 6: Boeing's opinion

From: Boeing Customer Support [mailto:csd.boecom@boeing.com]
Sent: Wednesday, September 22, 2010 12:28 AM
To: Ujlaki György
Subject: FW: ABORTED TAKE-OFF - SUSPECTED UNCOMMANDED RUDDER DEFLECTION
FROM: THE BOEING COMPANY
TO: Malev Hungarian Airlines Ltd. (HGA)
[MESSAGE NUMBER:HGA-HGA-10-0016-04B] Boeing Response
MESSAGE DATE: 21 Sep 2010 1528 US PACIFIC TIME / 21 Sep 2010 2228 GMT

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SUBJECT: FW: ABORTED TAKE-OFF - SUSPECTED UNCOMMANDED RUDDER DEFLECTION

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RESPONSE:

Please note that the information from message HGA-HGA-10-0017-01C was transferred to message HGA-HGA-10-0016-03C. Message HGA-HGA-10-0017-01C was cancelled.

1. Analysis of the FDR data indicates that the reported unexpected yaw motion was likely due to an atmospheric disturbance. This is discussed further in response item 4 below. However, we have no objection to performing the troubleshooting steps proposed by HGA.

2. Almost all reports of uncommanded/unexpected yaw events for approximately the past 5 years, on model 737, have been found to be caused by an atmospheric disturbance, based on analysis of FDR data. Similarly, analysis of the FDR data from the datum airplane indicates the reported yaw motion was likely due to an atmospheric disturbance.
Accordingly, we do not recommend any additional troubleshooting steps.

3. We do not recommend any operational limitation for other B737 aircraft in HGA's fleet, in response to the reported yaw motion and FDR analysis on the datum aircraft.

4. Ref /E/ FDR data plots are attached to this message. The following is a summary of our analysis and review of the FDR data submitted by HGA:
The data show the airplane experienced a lateral acceleration of approximately .15 g's to the right around time 6827 seconds. Coincident with the lateral acceleration spike, left rudder was commanded by the crew, as evidenced by the rudder pedal moving to the left synchronously with the rudder position. This is a normal correction for an acceleration and yaw to the right.
Just prior to the acceleration to the right, between times 6824 and 6826 seconds, a stagnation in airspeed was observed. Also, around the time of the spike in lateral acceleration, oscillations in vane angle of attack were noted, with the left and right vanes crossing over one another. These characteristics are indicative of an encounter with atmospheric disturbance, most likely a wind gust or wake turbulence. This disturbance was the cause of the airplane yaw to the right, and the airplane operated as expected.
We appreciate HGA providing the FDR data to assist in our evaluation.
If attachments are referred to, and are not present, please reply to this e-mail or contact your Boeing Field Service Representative.

Jeff Gekeler - Service Engineering Airplane Systems
Thomas D. Flynn - Service Engineering Manager
Commercial Aviation Services
The Boeing Company
The following files are attached to this message:
FDR data plots - YE322 20SEP2010.pdf

Appendix 7: NTSB's opinion

From: Sedor Joe [mailto:Joe.Sedor@ntsb.gov]
Sent: Thursday, October 07, 2010 1:38 PM
To: Eszes János
Cc: Olah Zsofia
Subject: RE: HA-LOE, B737-600, 09/20/2010, Hungary

Janos,
Attached is the plots of the FDR from the event takeoff.

NTSB staff have reviewed the data and agree with the Boeing analysis that the airplane experienced an external wind gust.

Please let me know what you would like us to do.

Best regards,
Joe

From: Eszes János [mailto:eszes.janos@kbsz.hu]
Sent: Monday, October 04, 2010 9:09 AM
To: Sedor Joe
Cc: 'Olah Zsofia'
Subject: HA-LOE, B737-600, 09/20/2010, Hungary

Dear Mr. Sedor,

I would like to introduce Ms Zsofia Olah, safety recommendations officer from EASA. They are too interested in the FDR data.
I would like to ask you whether it is possible that NTSB and EASA liaise directly, for practical reasons (provided NTSB has the FDR data from Boeing).
Please let me know if that way of data exchange is feasible.
Thank you.

Best regards,
Janos