AIRCRAFT ACCIDENT REPORT

4/2008 (ADC/2006/10/29/F)

Accident Investigation Bureau

Report on the Accident to
ADC Airlines, Boeing 737-2B7
Registration 5N-BFK at Tungar Madaki,Abuja on
29th October, 2006.

This report was produced by the Accident Investigation Bureau (AIB), Murtala Muhammed Airport, Ikeja, Lagos.

The report is based upon the investigation carried out by Accident Investigation Bureau, in accordance with Annex 13 to the Convention on International Civil Aviation, Nigerian Civil Aviation Act 2006, and Civil Aviation (Investigation of Air Accidents and Incidents) Regulations.
In accordance with Annex 13 to the Convention on International Civil Aviation, it is not the purpose of aircraft accident/serious incident investigations to apportion blame or liability.

Readers are advised that Accident Investigation Bureau investigates for the sole purpose of enhancing aviation safety. Consequently, Accident Investigation Bureau reports are confined to matters of safety significance and should not be used for any other purpose.

As the Bureau believes that safety information is of great value if it is passed on for the use of others, readers are encouraged to copy or reprint for further distribution, acknowledging Accident Investigation Bureau as the source.

Recommendations in this report are addressed to the regulatory Authorities of the state (NCAA). It is for this authority to decide what action is taken.

Content

Aircraft Accident Report No:	(ADC/2006 /10 /29/F)
Registered Owner:	Celtic Capital 22829 1900 Glades Road Suite 300, Bocaraton, Florida, 33431
Operator:	Aviation Development Company PLC 84, Opebi Road, Ikeja, Lagos
Aircraft Type and Model:	Boeing 737-2B7
Manufacturer:	Boeing Aircraft Company, USA
Date of Manufacture:	20th October, 1983
Registration:	5N-BFK
Serial No.:	22891
Place of Accident:	Tungar Madaki, Abuja 1.42NM from the ABC 'VOR' on radial 238 N 08 59.691' and E 007 14.772'
Date and Time:	29 October 2006 at 1130hrs *All times in this report are Local Time (equivalent to UTC + 1) unless otherwise stated*

SYNOPSIS

The Accident Investigation and Prevention Bureau (AIPB), now Accident Investigation Bureau (AIB) received notification of the accident at 1200hrs and investigations commenced same day. The States of the Aircraft, Engine Manufacture/Design and other stakeholders were notified same day.

Aviation Development Company (ADC), operator of the aircraft, was a scheduled transport airline.

The aircraft took off from Calabar on Sunday morning the 29th of October, 2006 and landed in Lagos. It then proceeded to Abuja where it landed at 1020hrs.

There was adverse weather at and around Abuja airport at the time the aircraft departed for Sokoto with 105 persons on board comprising 2 cockpit crew, 3 cabin crew and 100 passengers. Soon after the aircraft was airborne, several warning signals/sounds of "Wind shear" were recorded by the Cockpit Voice Recorder (CVR). In addition, the CVR recorded several "Terrain, terrain….pull up, pull up" sounds from the Ground Proximity Warning System (GPWS) as the aircraft was losing altitude. In the process of recovery, the aircraft was operated outside the safe flight envelope, which resulted in a stall close to the ground and crashed.

Out of the 105 persons on board, there were 96 fatalities and 9 survivors with minor injuries; there was no casualty on ground.

The investigation identified the following causal factor/contributory factors:

Causal Factor

The pilot's decision to take-off in known adverse weather conditions and failure to execute the proper windshear recovery procedure resulted in operating the aircraft outside the safe flight regime, causing the aircraft to stall very close to the ground from which recovery was not possible.

Contributory Factors

(1) Inability of the flight crew to apply windshear recovery procedures and the use of inappropriate equipment for windshear recovery procedure during simulator recurrrecncy. Lack of company Standard Operating Procedures (SOP) for flight operations in adverse weather conditions.

(2) The coordination of responsibilities between the pilot-flying (PF) and pilot not flying(PNF) during their encounter with adverse weather situation was inconsistent with Standard Operating Procedures (SOP) for the duties of the pilot-flying (PF) and pilot not

flying(PNF) resulting in the inadequate control of the aircraft.

Five safety recommendations have been made.

1.0 FACTUAL INFORMATION

1.1 History of the Flight

The B737-200 aircraft which night-stopped at Calabar on Saturday the 28th of October, 2006, departed for Lagos in the morning of the 29th of October, 2006, and landed in Lagos at 0825hrs. While on ground in Lagos, it uplifted some fuel. There was only cabin crew change. The aircraft departed Lagos on scheduled passenger service as ADK 063 at 0929hrs and landed in Abuja at 1020hrs.

The aircraft uplifted 5000 litres of fuel and had 11000kg fuel for departure as ADK 053, a scheduled service to Sokoto. After boarding, it started raining and this compelled the crew to close the aircraft doors. Shortly after the rain had subsided, the doors were opened for the ground personnel to disembark. The crew then requested for start-up clearance. At 1115hrs the aircraft was given a start up clearance for Sokoto.

At 1121hrs, the aircraft was given taxi clearance to holding position Runway 22. The pilot immediately requested for the wind, which was given as "210 variable at 8kts". Shortly after, the Control Tower transmitted the wind as south-westerly at 15kts. While taxiing, the control tower advised Flight ADK 053 of gusty wind. The wind was initially given as 35kts and then changed to 28kts within 1min. At 1125hrs while the aircraft was at the holding point, the crew was again advised of South-Westerly wind at 15kts. At this juncture, the pilot of Virgin Nigeria 042 was heard on the radio saying "it looks like 35kts to me" and then stated that he was going to wait for improvement in the weather, which he did. Thereafter, the ADK 053 crew requested for takeoff clearance and was cleared with right turn-out on course.

Flight ADK 053 was airborne at 1129hrs and was transferred to the Approach Control on 119.8MHZ but there was no acknowledgement from the crew. After three unsuccessful attempts to contact the aircraft, the Tower advised the Approach Control to call ADK 053. Other aircraft on the apron (Virgin Nigeria 042 and Trade Wings 2401), which were on that frequency were also asked to assist in contacting the aircraft but all attempts were unsuccessful.

Kano and Lagos Area Controls were requested to contact ADK 053, but there was no response from the aircraft. Abuja Flight Communication Centre was then advised to inform National Emergency Management Agency (NEMA) in Kano about the loss of contact with the aircraft.

At 1138hrs, Flight Communication Centre called the Control Tower that someone came from a nearby village (Tungar Madaki) near the radar site and reported that a plane had crashed in their village.

A search party from the airport was dispatched and they found and confirmed that the plane had crashed shortly after takeoff. The accident resulted in 96 fatalities out of 105 persons on board (POB).

The accident occured at latitude N 08 59.691' longitude E 007 14.772' on an elevation of 1123ft (ASL). The time of the accident was 1130hrs during daylight and in rain.

1.2 Injuries to Persons

Injuries	Crew	Passengers	Others
Fatal	4	92	0
Serious	1	1	0
Minor/None	0	7	

1.3 Damage to Aircraft

The aircraft was destroyed (See fig 1-1 and 1-2).

Fig 1-1 Photograph showing wreckage site

Fig 1-2 Photograph showing aircraft destruction

1.4 Other Damage

There was severe damage to the farm land and crops in the area of impact.

1.5 Personnel Information

1.5.1 The Captain

Date of Birth:	9th March, 1956
Nationality:	Nigerian
Gender:	Male
Licence No.:	ATPL 3049
Validity:	31st March 2007
Aircraft Ratings:	B737-200
Licence Proficiency Check:	Not Available
Last Recurrency:	Not Available

Total Flying Hours: 8545 as at 27thSeptember, 2006

Total Actual Command Time: 353:15 hours

Last medical:	27th September, 2006
Last Simulator:	20th September, 2006
Simulator Facility Used:	(Sabena Flight Academy, Brussels, Belgium)
Simulator Validity:	Until 19th March, 2007
Last 90 days:	195:30 hours
Last 7 days:	Not Available
Last 24 hours	Not Available

1.5.2 The First Officer

Date of Birth:	19th June, 1952
Nationality:	Nigerian
Gender:	Male
Licence No.:	ATPL 2846
Validity:	30th March, 2007
Aircraft Ratings:	PA-31, HS-125, B737
Licence Proficiency Check:	Not Available
Last Recurrency:	Not Available
Total Flying Hours:	6497:50 as at 29th September, 2006
Last Medical:	29th September, 2006
Last Simulator:	11th September, 2006
Simulator Facility Used:	(Sabena Flight Academy, Brussels, Belgium)
Simulator Validity:	Until 10th March, 2007
Total Time on Type:	Not Available.
Last 90 days:	254:45 hours
Last 7 days:	Not Available
Last 24 hours:	Not Available

1.6 Aircraft Information

1.6.1 General Information

Type:	B737-2B7

Serial No.:	22891
Manufacturer:	Boeing Aircraft Company, USA
Date of Manufacture:	20th October, 1983.
TSN:	56411:09 hrs
CSN:	44465
C of A Validity:	2nd September, 2007

The last C-check on the aircraft was accomplished on the 28th of July, 2005 at total hours of 54337. The next C-check was to be due at the calendar time of 27th January, 2007 or 57337 hours.

1.6.2 Power Plant

Two Pratt & Whitney Engines

	Engine No.I	**Engine No. II**
Model:	JT8D-17	JT8D-17A
Serial No.	P707128	P709552
TSN/CSN:	43962hrs/27746	49623hrs/27214
TSO/CSO:	1653hrs/1639	1338hrs/1471

- **Engine I**

The engine was last overhauled on the 17th of November, 2005 by New Jet Engine Services, Miami, Florida, and installed on the aircraft on the 22nd of November, 2005, at TSN/CSN 42498 hrs/26107 and TSO/CSO 0hr/0 Cycle.

- **Engine II**

Engine was last overhauled on the 13th of January, 2006, by Aviation Engines Services Miami, Florida, and installed on the 14th of February, 2006 at TSN

48285 hrs and CSN 25743 Cycles and TSO/CSO 0 hr / 0 Cycle.

There were no known defects in the technical logbook.

1.6.3 **Type of fuel used:** Jet A1

1.6.4 **Weight and Balance Data:** The aircraft was loaded within permissible weight and balance limitation.

1.6.5 Horizontal Stabilizer Trim System

The horizontal stabilizer trim control system provides longitudinal trim of the airplane by varying the angle of attack of the horizontal stabilizer. It is moved through 17 degrees of travel by means of a jackscrew and ball nut. This jackscrew is normally driven by either a main electric motor, a secondary (autopilot) motor, or manually by a crank on either side of the center isle stand in the flight deck. The crank is connected to the jackscrew gearbox by a cable system which runs the length of the airplane. These cables also provide feedback indication to the flight crew on the position of the stabilizer.

The stabilizer must be positioned in the 'green band'(2.8 and 9.0 units of trim) on the flight deck indicator for takeoff. If a takeoff is attempted with the stabilizer trim outside of this range, an aural alert will sound.

1.7 Meteorological Information

1.7.1 The meteorological and SPECI reports available before, during and after departure of the aircraft at Abuja as issued by NIMET were as follows:

Time:	**10:00 UTC**
Wind:	270/06kts
Visibility:	15km
Weather:	Nil

Cloud:	Broken 360m
Temperature:	30˚C
QNH:	1011 HPA
Trend:	No significant change
Time:	**10:13 UTC (SPECI)**
Wind:	280/06kts
Visibility:	5000M
Weather:	Slight rain
Cloud:	Broken 360m
Temperature:	30˚C
QNH:	1011 HPA
Trend:	TEMPO QBA; 3000m
Time:	**10:25 UTC (SPECI)**
Wind:	240/15kts
Visibility:	3000m
Weather:	Heavy rain
Cloud:	broken 300m
Temperature:	30˚C
QNH:	1011 HPA
Trend:	TEMPO QBA; 1500m
Time:	**10:30 UTC**
Wind:	270/15 kts

Visibility:	3000m, 5000m [W-NE]
Weather:	Slight rain
Cloud:	Broken 300m
Temperature:	30˚C
QNH:	1011 HPA
Trend:	TEMPO QBA; 3000m
Time:	**11:00 UTC**
Wind:	270/05kts
Visibility:	8km
Weather:	Nil
Cloud:	SCT 330m, FEW 600m CB(W-NW) BKN 3000m
Temperature:	25˚C
QNH:	1010 HPA
Trend:	TEMPO THUNDER

1.7.2 Satellite Weather Imagery

AIB requested a meteorological summary from the Boeing Company's Atmospheric Sciences Department. No ground station information for Nigeria was publicly available; the analysis is based on available satellite weather imagery. This data shows that only scattered low-top cumulus and insignificant cloud development was seen between 09:30-09:45 UTC. However, explosive convective development commenced sometime between 09:45 and 11:00 UTC. Conditions evolved from scattered low-top cumulus to an isolated convective cell with estimated tops to above

45000ft in just over an hour. Between 11:00 UTC and 11:30 UTC, the cell continued to intensify with estimated tops increasing to above 50000ft, while anchored over Abuja (little or no horizontal motion detected).
The accident occurred in daylight and in rain.

1.8 Aids to Navigation

The navigation and landing aids available and their effectiveness on the day of accident were as follows:

"ABC" VOR/DME on 116.3MHZ CH110X – Serviceable

"IAB" ILS/DME on 109.3MHZ CH30X –
Localizer - Serviceable
Glide slope - Serviceable
DME - Unserviceable

"IAC" ILS/DME on 111.9MHZ CH56X –
Localizer - Serviceable
Glide slope - Serviceable
DME - Serviceable

"AG" Locator 321KHZ - Unserviceable
Radar - Unserviceable

1.9 Communications

There was good communication between the aircraft and the Control Tower before and during its departure. The status of the equipment on that day were as follows:

VHF 118.6MHZ Control Tower – Serviceable

VHF 121.7MHZ Domestic Freq. – Serviceable

VHF 119.8MHZ Approach Control - Serviceable

VHF 127.05MHZ ATIS Freq. – Serviceable

HF 9104KHZ – Serviceable

Intercoms – Serviceable

Satcom link with other Stations – Serviceable

1.10 Aerodrome Information

Abuja airport has an elevation of 1123ft above sea level and the runway orientation of 04/22, which was 3610m long and 60m wide, located on latitude 09°00'25"N longitude 007°15'47"E. The runway was also equipped with precision approach path indicator (PAPI), edge and approach lights (see fig. 1-3). The aircraft crashed at 1.42 NM from the ABC 'VOR' on radial $238^{0.}$ The co-ordinates are N 08 59.691' and E 007 14.772'.

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Notice: After 9 Nov 2006 0901Z, this chart may no longer be valid. Disc 21-2006

JEPPESEN
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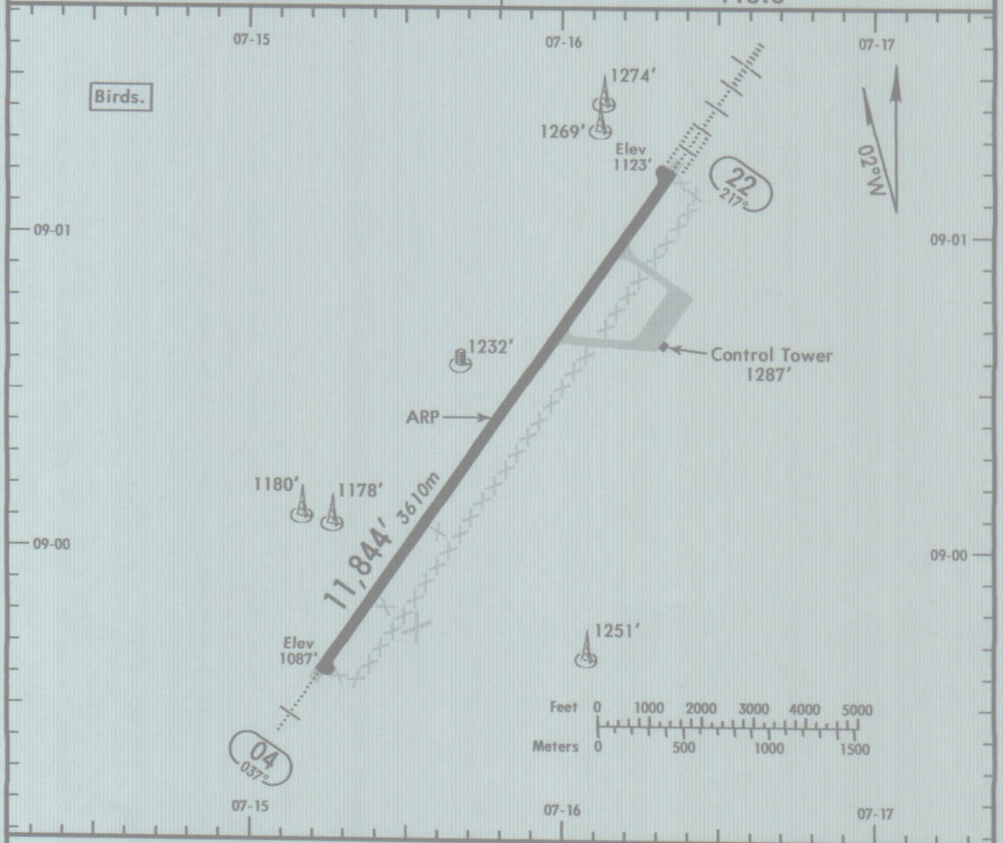
DNAA/ABV
Apt Elev **1123'**
N09 00.4 E007 15.8

JEPPESEN
3 MAR 06 (10-9)

ABUJA, NIGERIA
NNAMDI AZIKIWE INTL

ATIS	Tower
127.05	118.6



ADDITIONAL RUNWAY INFORMATION

RWY		USABLE LENGTHS LANDING BEYOND Threshold	Glide Slope	TAKE-OFF	WIDTH
04	RL HIALS VASI (3 bar)		10,780' 3286m		197' 60m
❶ 22	RL HIALS-II VASI (3 bar)		10,666' 3251m		

❶ Blast pads 213'/65m at both runway ends.

TAKE-OFF & DEPARTURE PROCEDURE

AIR CARRIER (JAA)

	Rwy 22 LVP must be in force RCLM (DAY only) or RL	Rwy 22 RCLM (DAY only) or RL	Rwy 04 RCLM (DAY only) or RL
A	250m	400m	400m
B	300m		
C			800m
D	400m		

FOR FILING AS ALTERNATE

	All Rwys Precision	Rwy 04 Non-Precision	Rwy 22 Non-Precision
A	800'- 3200m	1300'- 3200m	1800'- 3200m
B			
C		1300'- 4000m	1800'- 4000m
D			

CHANGES: Communications.

Fig. 1-3 Data showing Abuja airport layout

1.11 Flight Recorders

1.11.1 Cockpit Voice Recorder (CVR)

The airplane was equipped with a Fairchild model A100A CVR, P/N 93-A100-80, S/N 61343 and manufactured in May, 1993. The CVR was sent to the National Transportation Safety Board's (NTSB) laboratory in Washington DC, for readout and evaluation. The CVR was played back normally and found to contain good quality audio information. (See fig. 4-1).

Fig 4-1 **Cockpit Voice Recorder (CVR)**

1.11.2 Flight Data Recorder (FDR)

The airplane was equipped with a Fairchild model, solid state FDR, F1000, P/N S603-1000-00, S/N 00402, and manufactured in March, 1993. The FDR recorded 18 airplane flight information (including altitude, airspeed, heading, wind direction and speed, control wheel and column position, elevator/aileron/rudder positions, engine fan speed, thrust reverser status and position, thrust reverser interlock, brake pressure, and autobrake status) in a digital format using solid state memory devices. It was recovered in good condition and also sent to the National Transportation Safety Board laboratory for readout and evaluation. The recorder contained good data; however, several parameters were unable to be extracted. (See fig. 4-2).

Fig 4-2 Flight Data Recorder (FDR)

1.12 Wreckage and Impact Information

The left wing of the aircraft had the first contact with a tree branch and immediately a portion of the leading edge structure was severed from the wing as evident at the crash site, thereafter the aircraft impacted the ground. Evidence indicated that the impact was nose low and in an extreme left bank. The airplane disintegrated and much of the center wing box and attached right wing caught fire. (See fig. 1-4 and fig. 1-5).

Fig 1-4 Arrow showing first contact with the tree before ground

Fig 1-5 Wreckage trail from the first impact with the ground

1.13 Medical and Pathological Information

The victims died due to injuries and fire burns suffered after the impact.

1.14 Fire

The aircraft impacted the ground, disintegrated and a portion (center wing box and attached right wing) caught fire. There was evidence of aircraft fluid spillage covering a wide area at the crash site.

The Abuja airport rescue and fire fighting service was category VIII. Twenty (20) handheld fire extinguishers were used during the rescue operation. A total of 10 fire service personnel from both the domestic and international wing were mobilized to the site at 1138 hrs. Thereafter, the vehicle got stuck on the way and that necessitated the use of portable handheld fire extinguishers in putting off some pockets of fire at the crash site by 1153hrs. (See fig.1-6 and fig.1-7).

Fig 1-6 Photograph showing aircraft wreckage consumed by fire

Fig 1-7 Photograph showing evidence of fire

1.15 Survival Aspect

Ninety six of the one hundred and five persons-on-board were fatally injured by impact forces and post-crash fire as the majority of the fuselage section of the aircraft was destroyed, while one cabin crew, aft seated, survived along with eight other passengers as the structure in their immediate environment remained substantially intact to the extent that a liveable volume was available throughout the crash.

For an accident to be deemed survivable, the forces transmitted to occupants through their seat and restraint system cannot exceed the limits of human tolerance, and the structure in the occupants' immediate environment must remain substantially intact to the extent that a liveable volume is provided for the occupants throughout the crash. (See fig. 1-8 and fig. 1-9).

Fig 1-8 Photograph of damaged aircraft showing the area where the few survivors were found

Fig 1-9 Photograph of damaged aircraft showing cabin debris and seats where the few survivors were found

1.16 Test and Research

1.16.1 Windshear Computer Examination

The onboard windshear computer manufactured by Honeywell, Part number 4068058-914, Serial number 92010516 (as per maintenance documents) was retrieved from the wreckage and then shipped to Honeywell Aerospace, Phoenix, Arizona through the NTSB in Washington, D.C. (See fig. 4-5).

Fig 4-5 Windshear computer

The airworthiness group met at the Honeywell Aerospace facility in Phoenix, Arizona, on July 31, 2007, to complete the examination of the windshear computer removed from the accident airplane. The examination was completed in two phases, one by Honeywell prior to the group meeting, and another during the group meeting.

In preparation for the examination of the computer, the group authorized Honeywell to conduct several recovery efforts on the windshear computer. Upon receipt and verification, the condition of *the accident unit was evaluated, including the condition of the non-volatile memory devices (A1U31 and U36 EEPROM) to determine if the devices can be safely removed from the original A1 card.*

The A1 card was then conditioned for safe removal of the non-volatile memory devices. To condition the card, a controlled environmental chamber oven was used to heat and dry the card components. Afterwards, the original memory devices were removed from the card by melting the device solder and then separating the devices from the A1 card. Using a device-programming tool, the data from each device was first downloaded for storage and then recorded, using the same utility tool, onto two new devices to create replicas of the original devices. The replica devices were then installed onto Honeywell Engineering Unit's A1 card. Finally, the data from the replicated devices was retrieved, using normal download techniques, into Honeywell's Event Analysis Tool.

1.16.2 Examination Results of the Windshear Component

Using the Honeywell Event Analysis Tool, the recorded flight fail codes/fault log history was decoded and examined. For flight leg 00, considered to be the accident flight, the following two flight fail codes were recorded:

Accident Flight Fail Code 1

Flight Number: *00*

Mode: *0*

Failure: *B6 (Roll 2 range test)*

Accident Flight Fail Code 2

Flight Number: *00*

Mode: *0*

Failure: *B2 (Roll 1 range test)*

According to Honeywell, the roll range test is considered failed if the windshear computer determines that the roll data input exceeded a limit of +/- 60º. The mode number 0 indicates that the windshear computer was "not standby". Examination of the windshear computer logic and flight data recorder information suggested that the windshear computer was likely in takeoff mode, which indicates weight off wheels, altitude less than 1500ft above field level, or less than 3 mins since weight off wheels.

The remainder of the recorded flight fault history was recorded in flights 02 to 91. The other flight fault recorded in "not standby" mode was a "Roll comparison Failure" recorded on flight leg 04. All the remaining flight faults were recorded while the windshear computer was in mode 8, or standby mode, and were either the following codes:

Altitude reference 1 Valid

Altitude reference 2 Valid

Synchro reference 5 Test

Synchro reference 2

Synchro reference 4

1.17 Organizational and Management Information

1.17.1 The Flight Operation Structure of the Airline

The structure of the safety/quality management of the airline was tailored to suit the requirement of the regulatory authority. This requirement was to put safety first before any other business. The safety manager was charged with specific duties to uplift the standard in accordance with the laid down rules and regulations.

The airlines safety/quality department was saddled with the duty of providing safety overview of the airlines operations. The safety manager was mandated to report directly to the chief executive officer.

1.17.2 The Safety/Quality Manager was to ensure the following:

- *Coordinate all effects of the relevant sections of flight operations department regarding safety matters in cooperation with ground support services and ground crew training.*

- *Supervise aircraft handling regarding matters relating to safety, in cooperation with ground support and ground crew training.*

- *To test the knowledge of all flight and cabin crews regarding emergency procedures and supervision of safety training.*

- *To issue and check the validation of all the "Emergency Proficiency, and first aid certificates", for crew members.*

- *The realization of all other duties of a safety/quality coordinator, like promulgation of flight safety bulletins to the flight crews and the authority, international exchange of experience and dealing with safety threats (sabotage) etc.*

- *Spot checks of stored flight documents of schedules and charter flights.*

- *Assist the maintenance unit in disposition and security of safety and emergency equipment.*

1.17.3 Cabin safety coordinator whose responsibilities are as follows:

(i) Monitor airlines operations for compliance with regulatory requirement.

(ii) Conduct weekly inspection on cabin safety and emergency equipment on the entire airline's aircraft.

(iii) Ensure that cabin safety and emergency equipments are in compliance with regulatory requirements.

(iv) Audit airline's operation safety at regular intervals.

(v) Coordinate accident prevention programme in cooperation with the Chief Pilot.

(vi) Monitor the quality of operation and operation personnel.

(vii) *Process occurrence and other safety related reports and investigate flight irregularities.*

(viii) *Coordinate the quality system of the Airline within the flight operations department.*

1.17.4 Airline's Quality System Policy

The airline shall provide safe and efficient operations. Airline shall achieve this end by always striving to improve the systems, procedures and processes. This effort shall be applied to all activities in the way airplanes are flown, how they are maintained, in the way of interaction with customers, regulatory authorities, suppliers and all who have a stake in the airline.

The airline shall employ the most qualified people, invest in their training and continue upgrade in the information made available to them. This would be charged with the responsibility of achieving quality goals. The airline shall strive to employ all the latest technology to get work done in the most efficient and effective manner.

1.17.5 Quality System

The quality system is composed of three (3) main managerial processes, planning, control and improvement.

Quality Planning

(i) Determine who the end user was.

(ii) Determine the need of the end user.

(iii) Develop features that will meet these needs.

(iv) Develop procedures and processes that will meet these needs.

(v) Put plans into use.

Quality Control

(i) Evaluate actual performance of the procedures, process or system.

(ii) Compare actual with planned goals.

(iii) Act on the difference.

Quality Improvement

(i) Identify specific needs for improvement.

(ii) Establish teams with clear responsibilities.

(iii) Provide resources, motivation, and training needed.

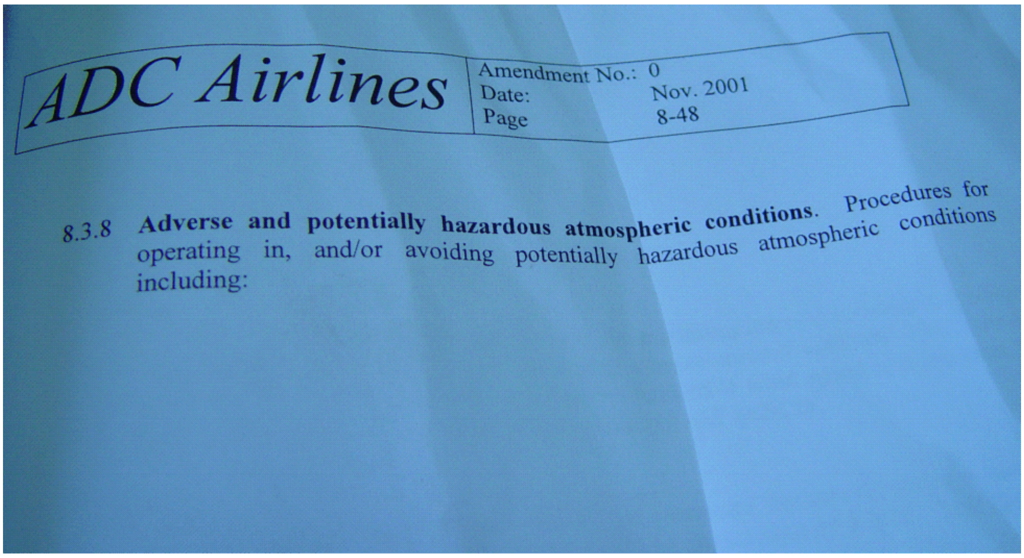
1.17.6 Interpretation of Meteorological Information to Enhance Safety

All flight crew are required to develop and maintain a sound working knowledge of the system used for reporting airfield actual and forecast weather.

Routine weather reports are compiled hourly or half-hourly during the hours of operation of the reporting station.

1.17.7 Adverse and potentially hazardous atmospheric conditions

Adverse and potentially hazardous atmospheric conditions were left blank in the Airline's Operations Manual (Section 8.3.8). (See fig. 4-3).



ADC Airlines

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Date: Nov. 2001
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8.3.8 **Adverse and potentially hazardous atmospheric conditions.** Procedures for operating in, and/or avoiding potentially hazardous atmospheric conditions including:

Fig 4-3 ADC Policy on adverse weather operation - "nil"

1.17.8 *Crew Pairing*

Flight crew with low experience in operating position shall not be paired to operate on Airline's flights.

1.17.9 Low Experience

Crew with less than 1000 hours experience in operation were deemed to be low in flying experience on type.

1.17.10 The Regulatory Authority

The Regulatory Authority was charged with the responsibility of regulation and licensing in the aviation industry. The requirements to be a pilot or pilot-in-command were clearly stated in the Air Navigation Regulations (ANR).

The Authority had other departments charged with other responsibilities. The relevant departments pertinent to this investigation are Personnel Licensing, Operations and Training, and Airworthiness.

However, individual operators had their policies and criteria of upgrading pilots into captains or pilot-in-command, as stated in their approved manuals.

The airline detailed the procedure of a co-pilot's upgrade to captain in their flight crew training manuals. The first officer upgrade requires that the pilot must have some prescribed training tailored to the requirement of the Air Navigation Regulation (ANR). The Authority had the responsibility of monitoring compliance. The captain-to-be must undergo some training on the aircraft type which includes ground school, Cockpit Procedure Training (CPT), Simulator, aircraft training and line training. The successful completion depends on satisfactory assessment of the individual pilot's capability in satisfying the training standards.

1.18 Additional Information

The NCAA authorized training captain/ examiner

The training captain/examiner was a Nigerian, male, held a Nigerian ATPL NO.1429, type rated on C150, C172, Piper Aztec, B58, F28, A310, and B737-200. The instructor was also designated training captain and examiner for B737-200 by NCAA. He trained most of the company flight crew even though he was not a regular staff of the company.

During the cause of this investigation it was discovered that the same instructor/examiner was involved in the upgrade training of the captain of ADK 053(simulator training and checks, aircraft training and checks). The instructor was also responsible for the training of the first officer (simulator training and checks).

Captain of Virgin **Nigeria Flight 042**

At 1125hrs while the ADK 053 aircraft was at the holding point, the crew was again advised of south-westerly wind at 15kts. At this juncture, the pilot of Virgin Nigeria 042 was heard on the radio saying "it looks like 35kts to me" and then stated that he was going to wait for improvement in the weather, which he did. Thereafter, the ADK 053 crew requested for takeoff clearance and was cleared with right turn out on course.

During the post crash interview, the Virgin Nigeria 042 captain confirmed that they experienced 35kts wind from their location on ground. He also demonstrated the angle at which the rain was striking their aircraft.

1.19 **Useful or Effective Investigation Techniques**

Nil

2.0 ANALYSIS

2.1 Aircraft Information

The aircraft was registered in the name of Aviation Development Company PLC (ADC). All the documentations were in conformity with the requirements of the Regulatory Authority. The aircraft was a B737-2B7, Serial No. 22891 and the Certificate of Airworthiness was valid till 2nd September, 2007.

2.1.1 Flight Controls

The on-site examination of the horizontal stabilizer showed that the surface was in the extreme airplane nose up position (figure 4.4). If the takeoff were attempted with the stabilizer in this position, the Takeoff Warning System would have sounded. If the crew continued the Takeoff with the same configuration then a low altitude stall would likely have occurred shortly after takeoff.

Further investigation of the system showed that, whereas the aft cable drum position corresponded to the post impact stabilizer position (full airplane nose up), the forward cable drum showed a position of approximately 5.5 units of trim.

An examination of the weight and balance sheet prepared for the flight indicated a takeoff trim setting of 5.5 units. There were no sounds heard on the CVR consistent with the takeoff warning system. Therefore, it was determined that the stabilizer trim setting was correct for the takeoff and that the forces of breakup likely pulled the cable system such that the stabilizer was repositioned to the full airplane nose up position.

2.2 Maintenance History

The last C-check was carried out on the 28th of July, 2005 at the total hour of 54337. Check 'A' was carried out on the 11th of August, 2006 and check 'B' was carried out on the 23rd of September, 2006.

The next C-check was to be due on the 30th of January, 2007. New Jet Engines Services, Miami, Florida overhauled the engines on the 17th of November, 2005 and were installed on the aircraft on 22nd of November, 2005 at TSN/CSN 42498 hours/26107 cycles and TSO/CSO 0 hours/0 cycles.

There were no known defects in the technical logbook.

2.3 Aircraft Handling

The aircraft left Lagos enroute Sokoto. It refueled at Abuja, some passengers disembarked and some embarked for Sokoto. It was daylight operation in rain with gusty winds. Just before take-off, the crew confirmed expecting windshear, as evident from the Cockpit Voice Recorder (CVR). During the take-off, the intensity of the rain increased to heavy. The first sign of difficulty was heard on the CVR just two seconds after the first officer called “80kts”. The captain said ‘AH’ instead of saying ‘checked’. Four seconds after the landing gear was retracted there was V_2 call out. Two seconds after the V_2 call out by the first officer, wind shear warning was triggered because the aircraft was initially experiencing head wind (increased performance) to sudden tail wind (decreased performance).

In trying to recover from the horizontal and vertical windshear experienced by the aircraft, the crew pitched-up the aircraft to between 30^o and 35^o as revealed by the FDR (see fig. 4-4), thereby greatly exceeding the critical angle of attack. The aircraft then experienced stick-shaker as confirmed by the Cockpit Voice Recorder (CVR). As a result of the high pitch attitude, the airflow into the engines was disrupted causing the engine to experience compressor stall. Subsequent flight control inputs by the crew resulted in aircraft aerodynamic stall leading to altitude loss and ground impact. In the meantime, the Ground Proximity Warning System (GPWS) was warning “Terrain, terrain… pull up”, “Terrain, terrain… pull up”, “Sink rate”, as the aircraft was sinking, fast approaching the ground and was outside safe flight regime. As a result the aircraft stalled and crashed. The total flight time was 76 seconds.

Fig 4-4 Tail part of the aircraft showing horizontal stabilizer in the full nose up pitch altitude

Flight Data Recorder (FDR) analysis

The analysis showed that:

- The aircraft departed on a heading of approximately 220 degrees.

- Rotation was initiated at approximately 133kts. The Boeing Flight Crew Operating Manual shows V_1 to be 136kts and VR to be 138kts, for the event flight aircraft configuration.

- After lift-off, the airspeed appears to have briefly leveled off at 162kts, before quickly decreasing.

- At time 17133 seconds, the column was commanded airplane-nose-down, causing the airspeed to recover, but with a corresponding reduction in pitch attitude (to - 5 degrees) and rate of climb. After 4 seconds, the column was commanded airplane-nose-up. The altitude data became erratic beyond this point, due to the very high angle of attack of the aircraft during this time.

- After time 17150.7 seconds, the left and right Engine Pressure Ratio (EPR) values decreased, with the right engine recovering shortly afterwards and the left engine 4 seconds behind.

- The Flight Data Recorder (FDR) data ended during time 17159 seconds, presumably near the time of initial impact.

- The heading change to the right seen at time 17154 seconds appears to be incorrect. This heading error most likely resulted from a vertical gyro gimbal error inherent in older heading indicators during large bank angle maneuvers. The abrupt heading, pitch and bank angle changes recorded at time 17157 seconds most likely resulted from vertical gyro gimbal-lock when the aircraft exceeded a roll attitude of 90 degrees (See fig. 2-1 to fig.2-13).

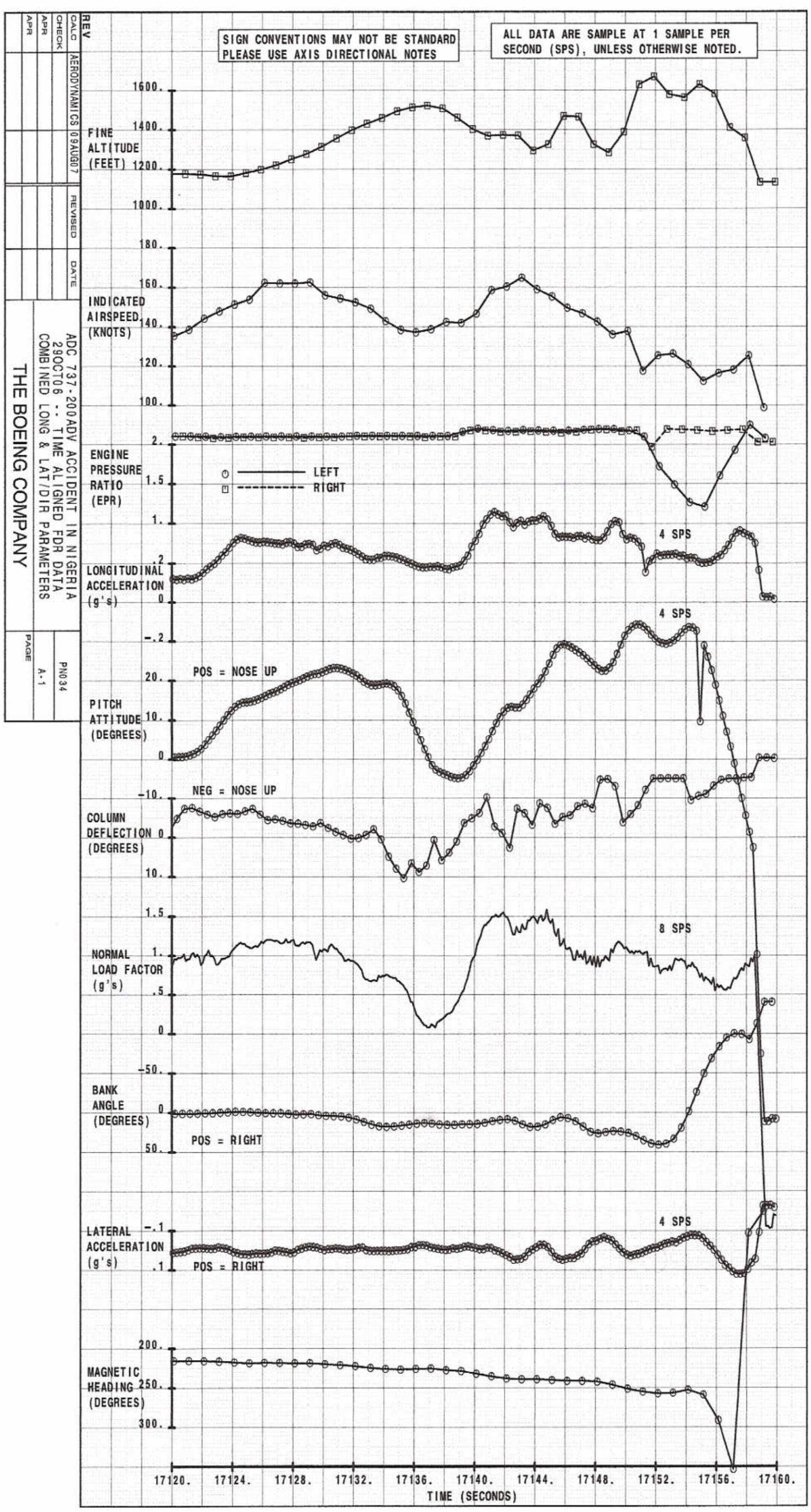


Fig 2-1 Time aligned FDR Data combined longitude and latitude/ directional

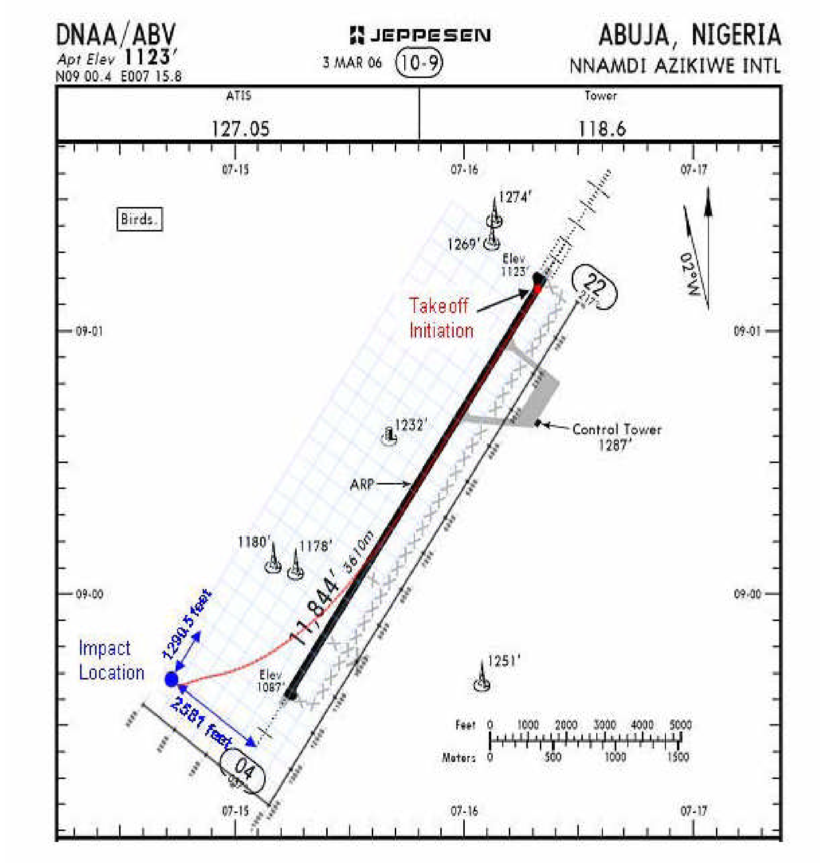


Fig 2-2 Abuja layout data showing the crash site relative to the airport.

Enclosure to B-H200-18292-ASI Investigation participants: Per ICAO Annex 13, do not release this information without Nigerian AIB consent.

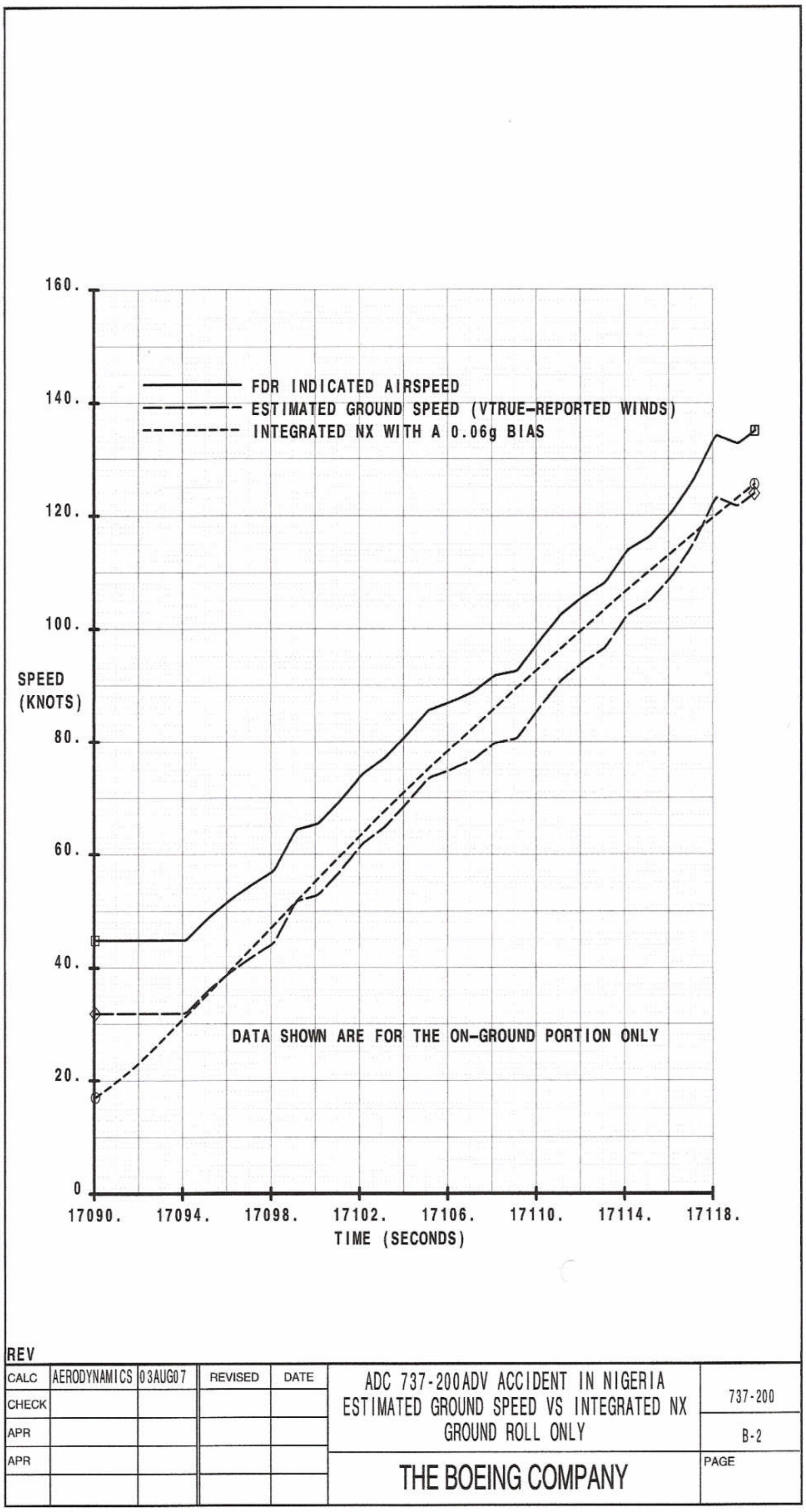


Fig 2-3 Shows FDR data showing estimated ground speed vs integrated Nx ground roll only.

Enclosure to B-H200-18292-ASI Investigation participants: Per ICAO Annex 13, do not release this information without Nigerian AIB consent.

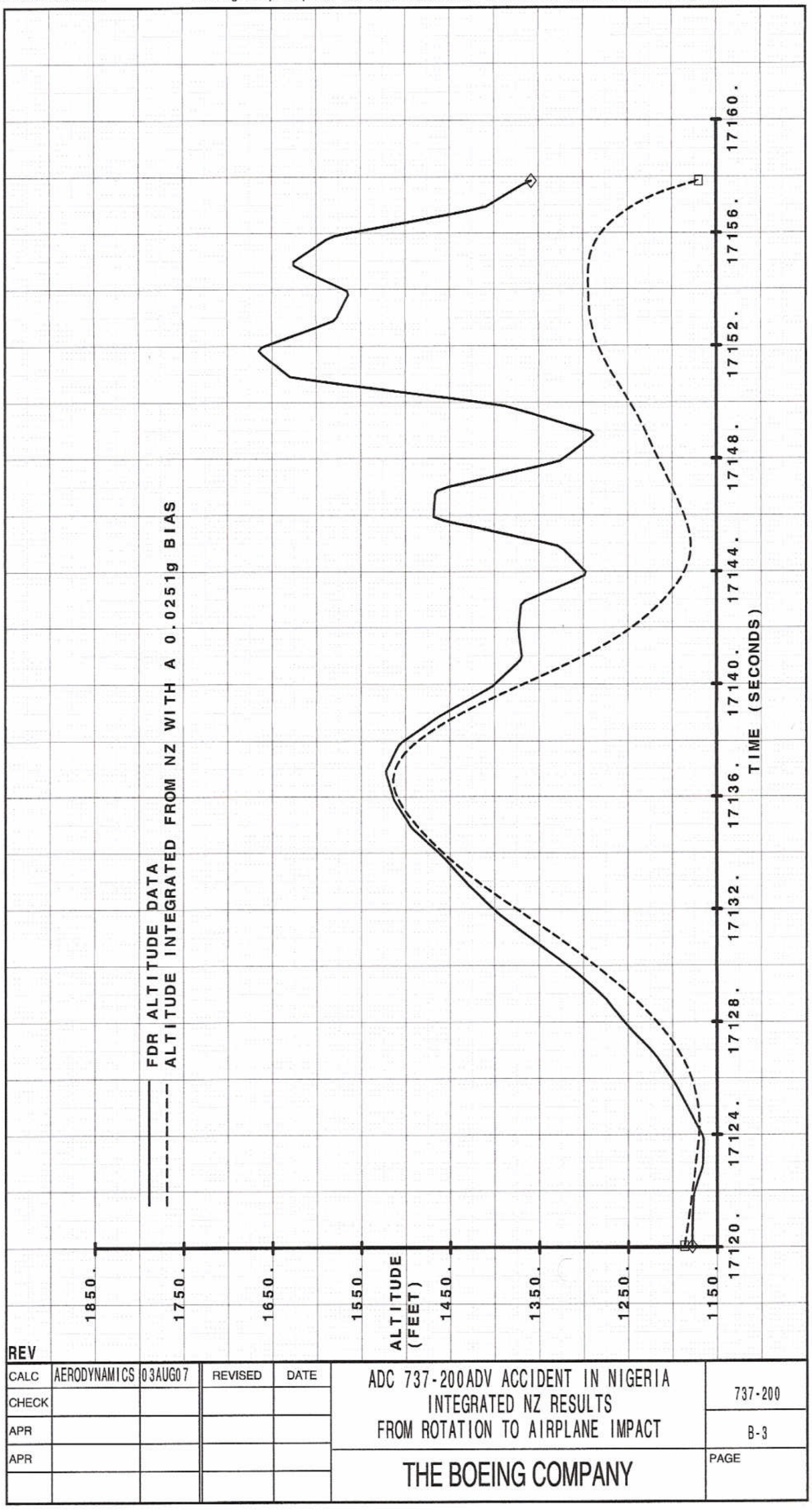


Fig 2-4 FDR altitude data showing integrated NZ results from rotation to airplane impact

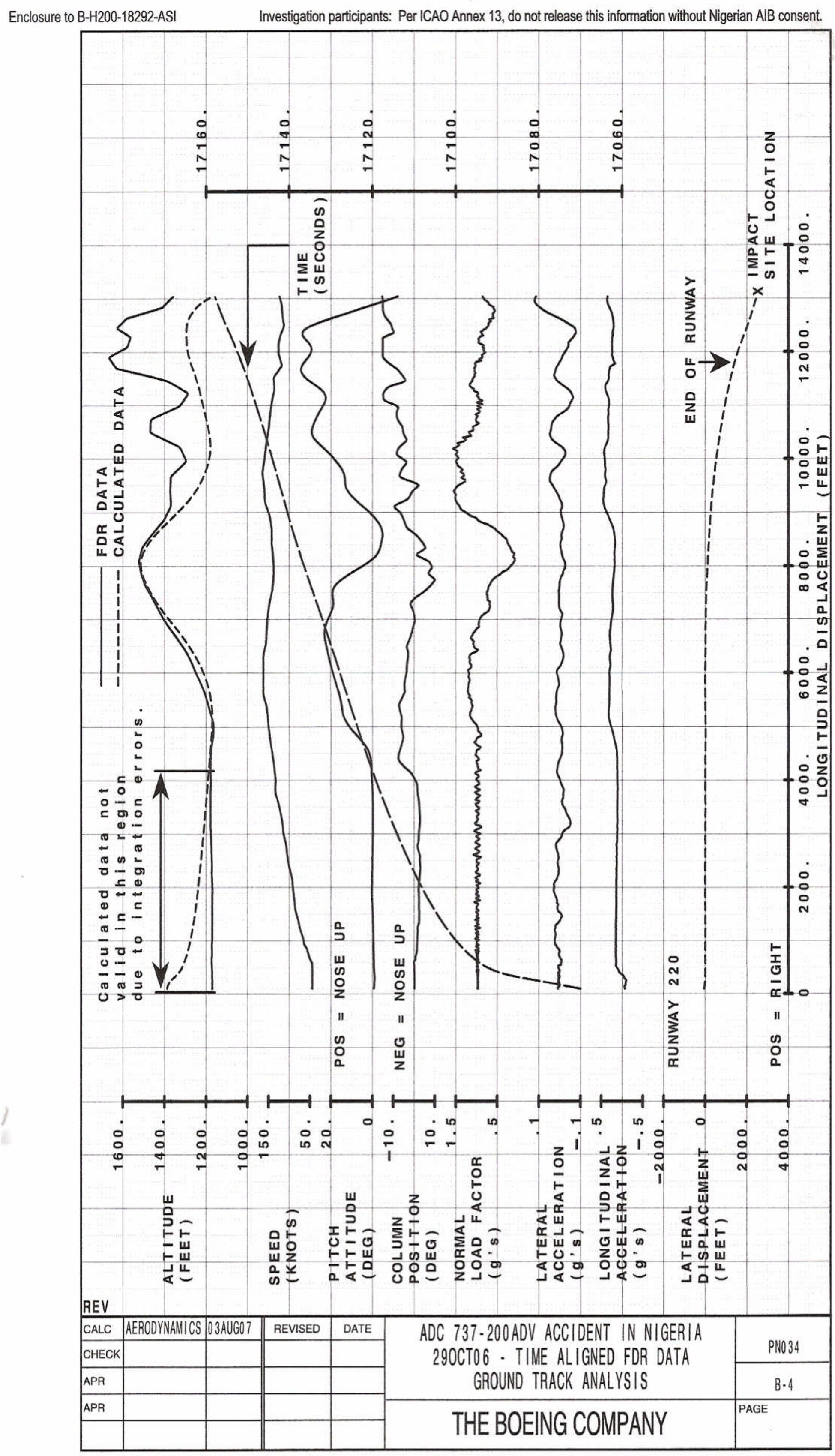


Fig 2-5 Time aligned FDR data showing ground track analysis

Enclosure to B-H200-18292-ASI Investigation participants: Per ICAO Annex 13, do not release this information without Nigerian AIB consent.

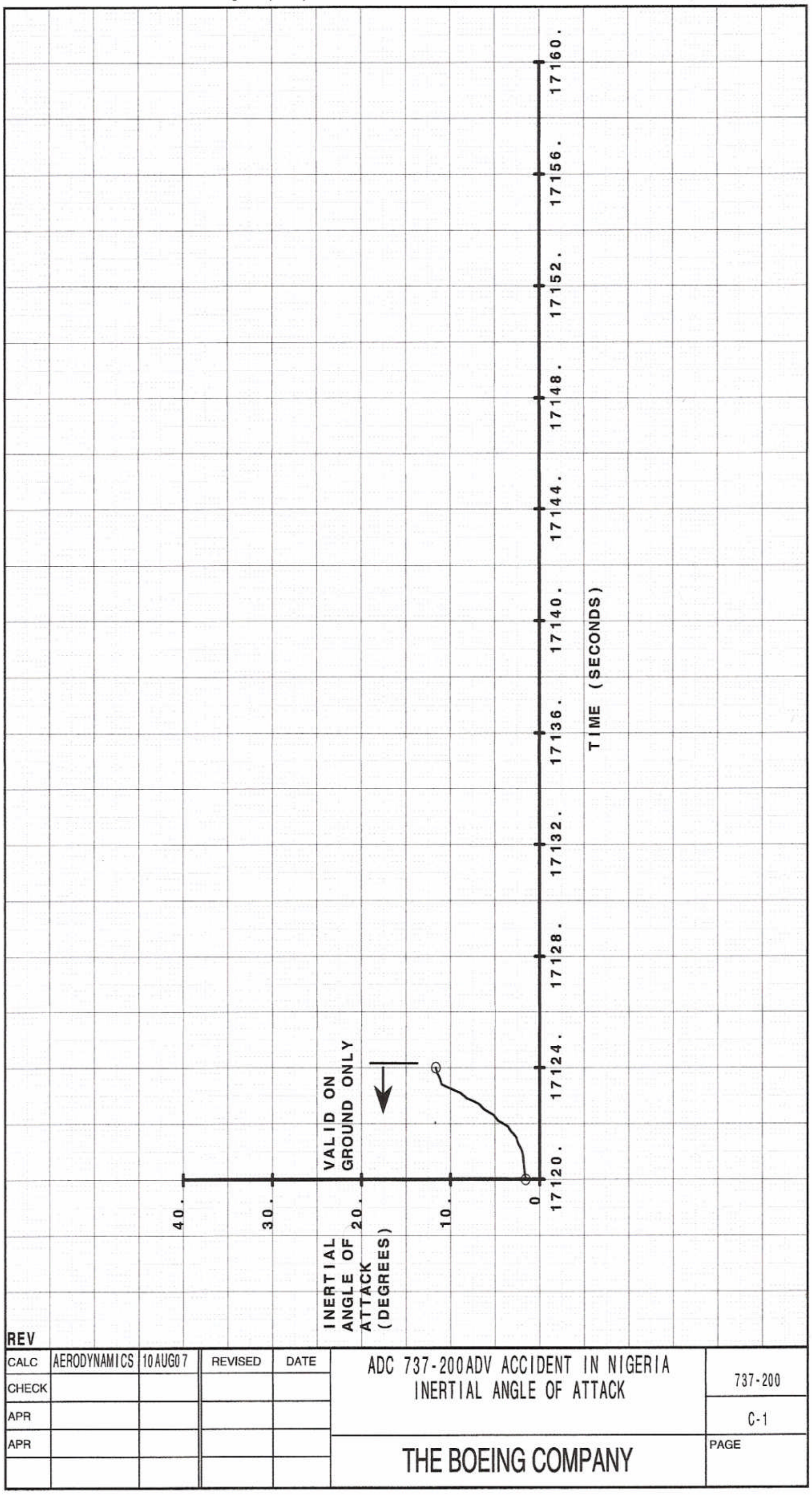


Fig 2-6 FDR data showing initial angle of attack

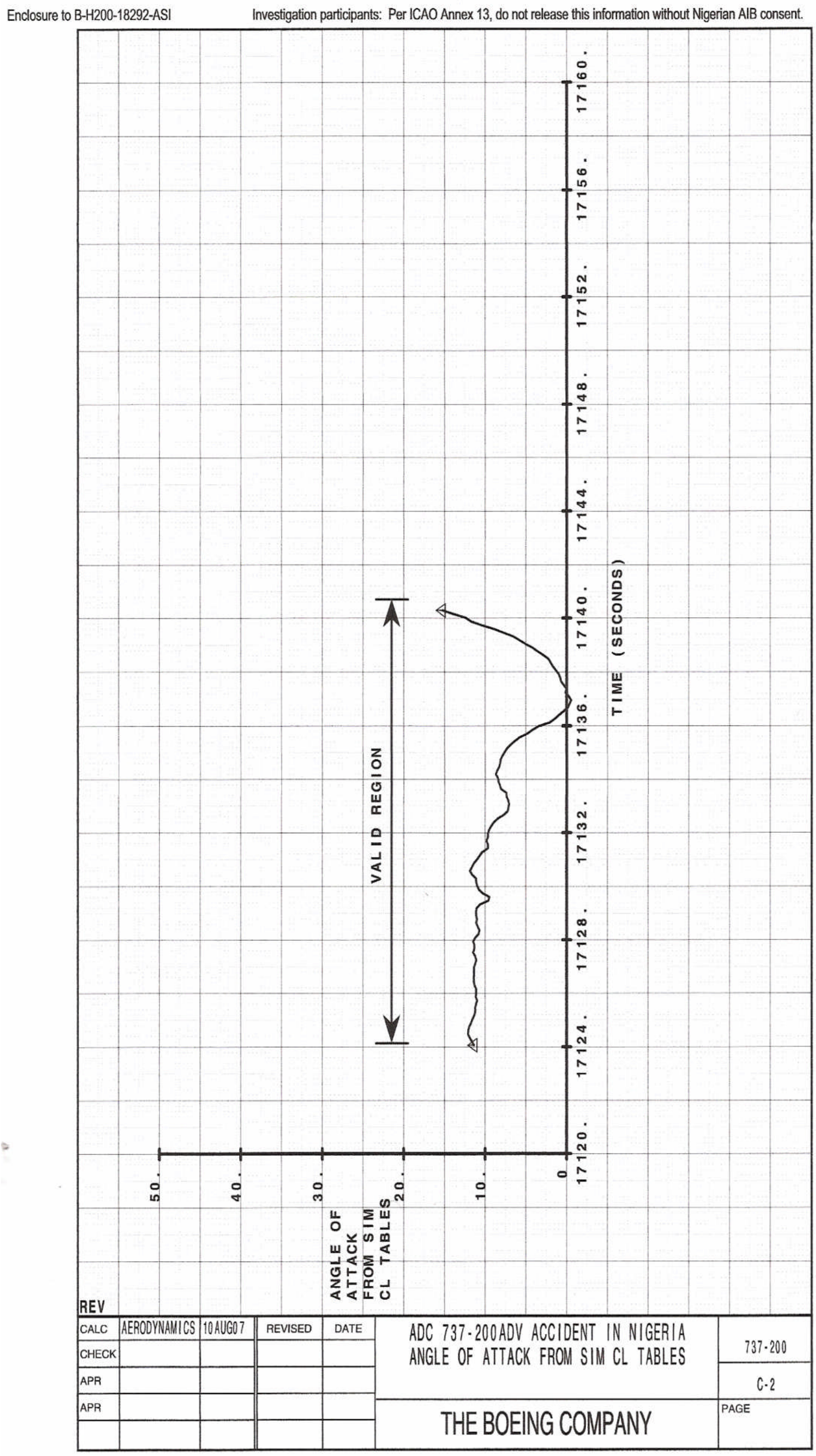


Fig 2-7 FDR data showing angle of attack

Enclosure to B-H200-18292-ASI   Investigation participants: Per ICAO Annex 13, do not release this information without Nigerian AIB consent.

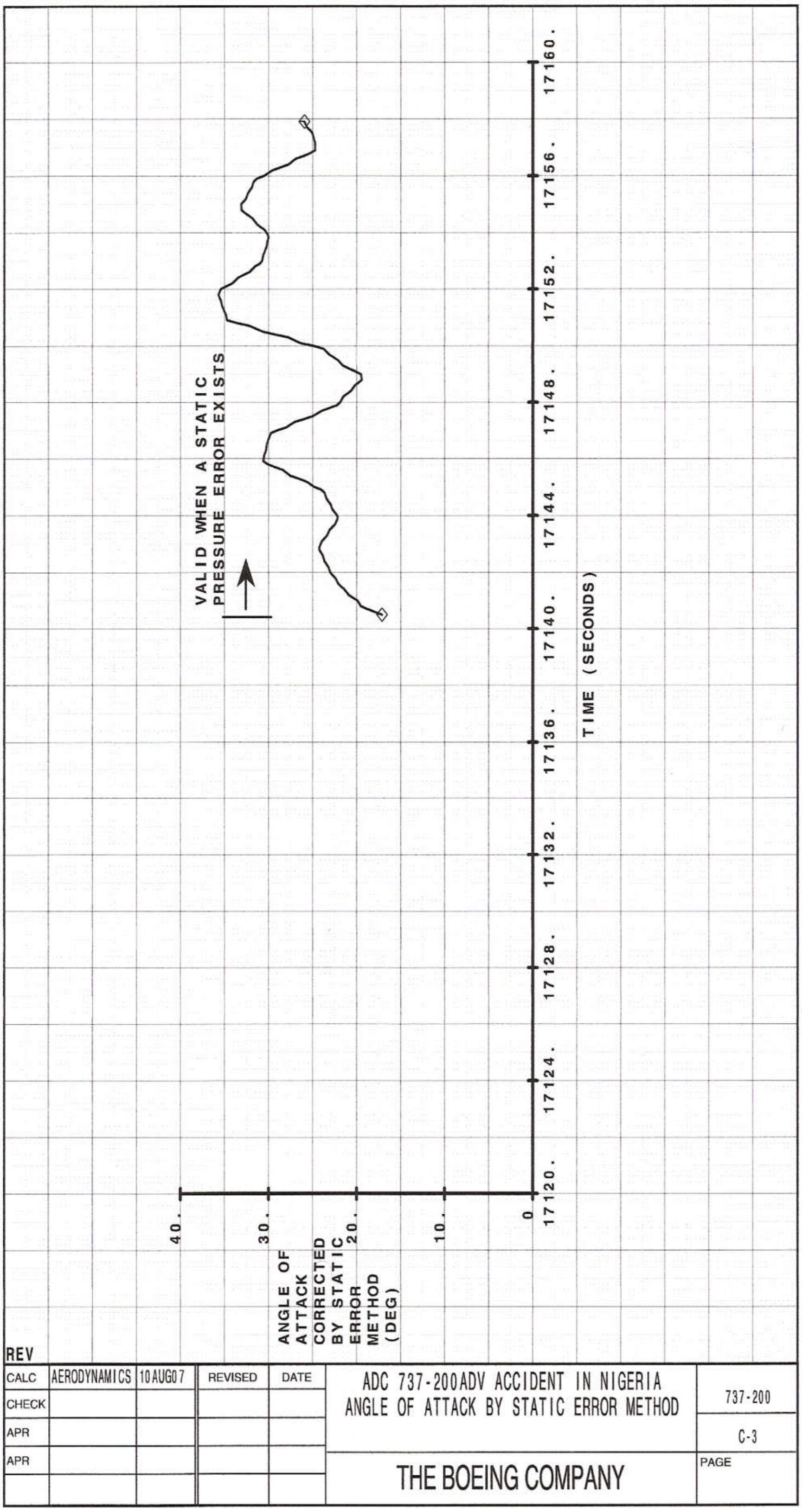


Fig 2-8 FDR data showing angle of attack by Static Error Method

Enclosure to B-H200-18292-ASI Investigation participants: Per ICAO Annex 13, do not release this information without Nigerian AIB consent.

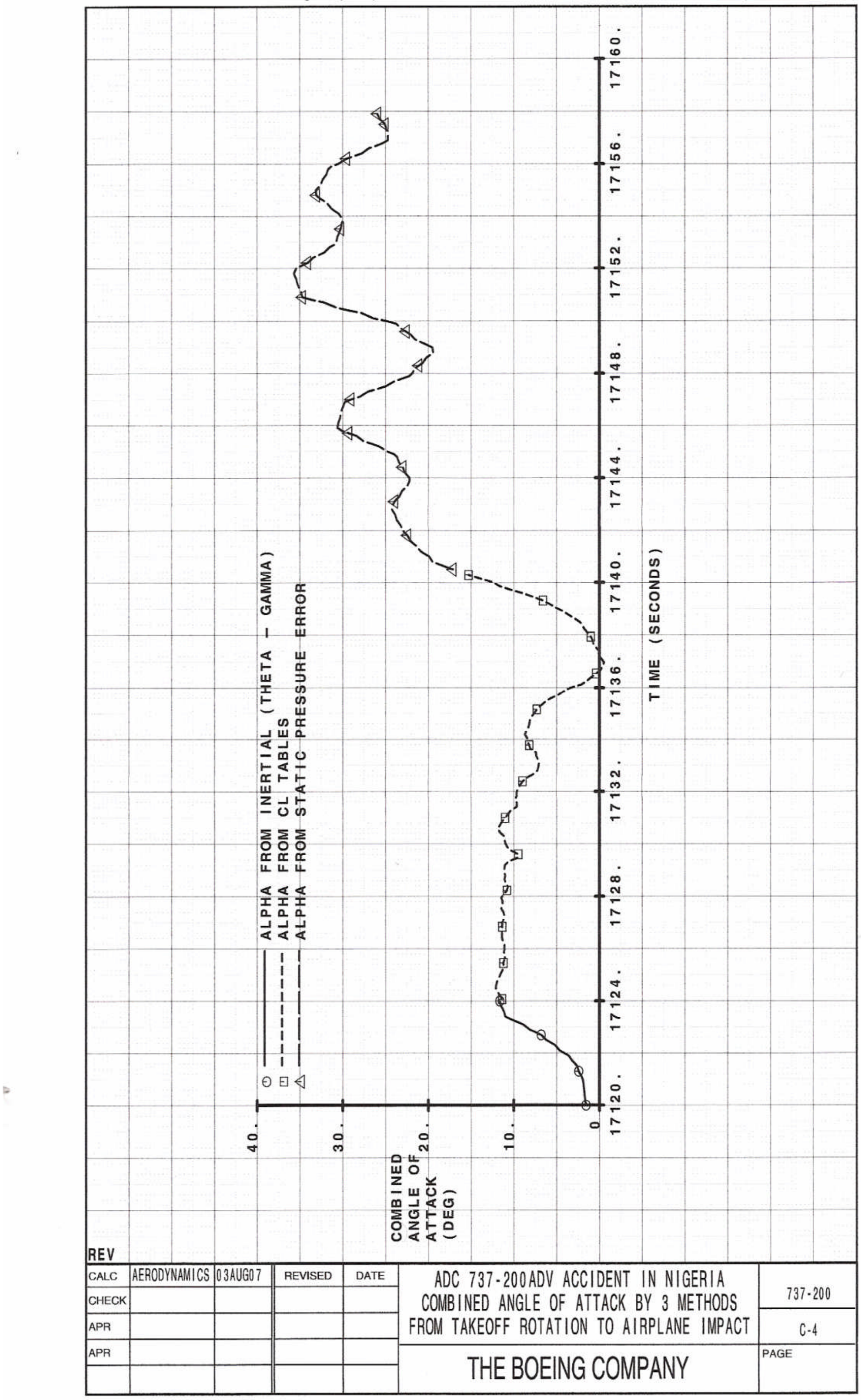


Fig 2-9 FDR data showing combined angle of attack by 3 methods from takeoff rotation to airplane impact

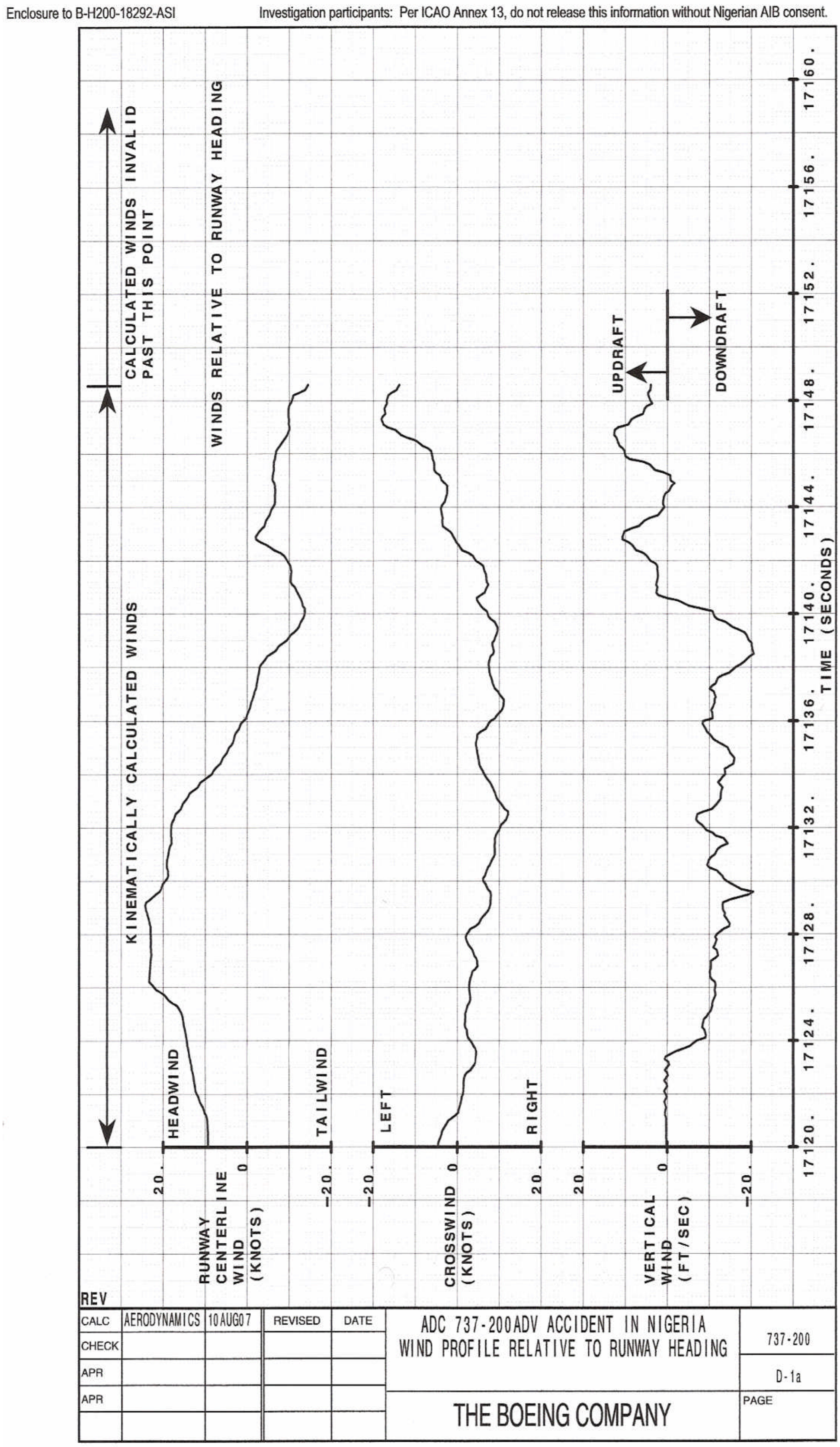


Fig 2-10 FDR data showing wind profile relative to runway heading

Enclosure to B-H200-18292-ASI

Investigation participants: Per ICAO Annex 13, do not release this information without Nigerian AIB consent.

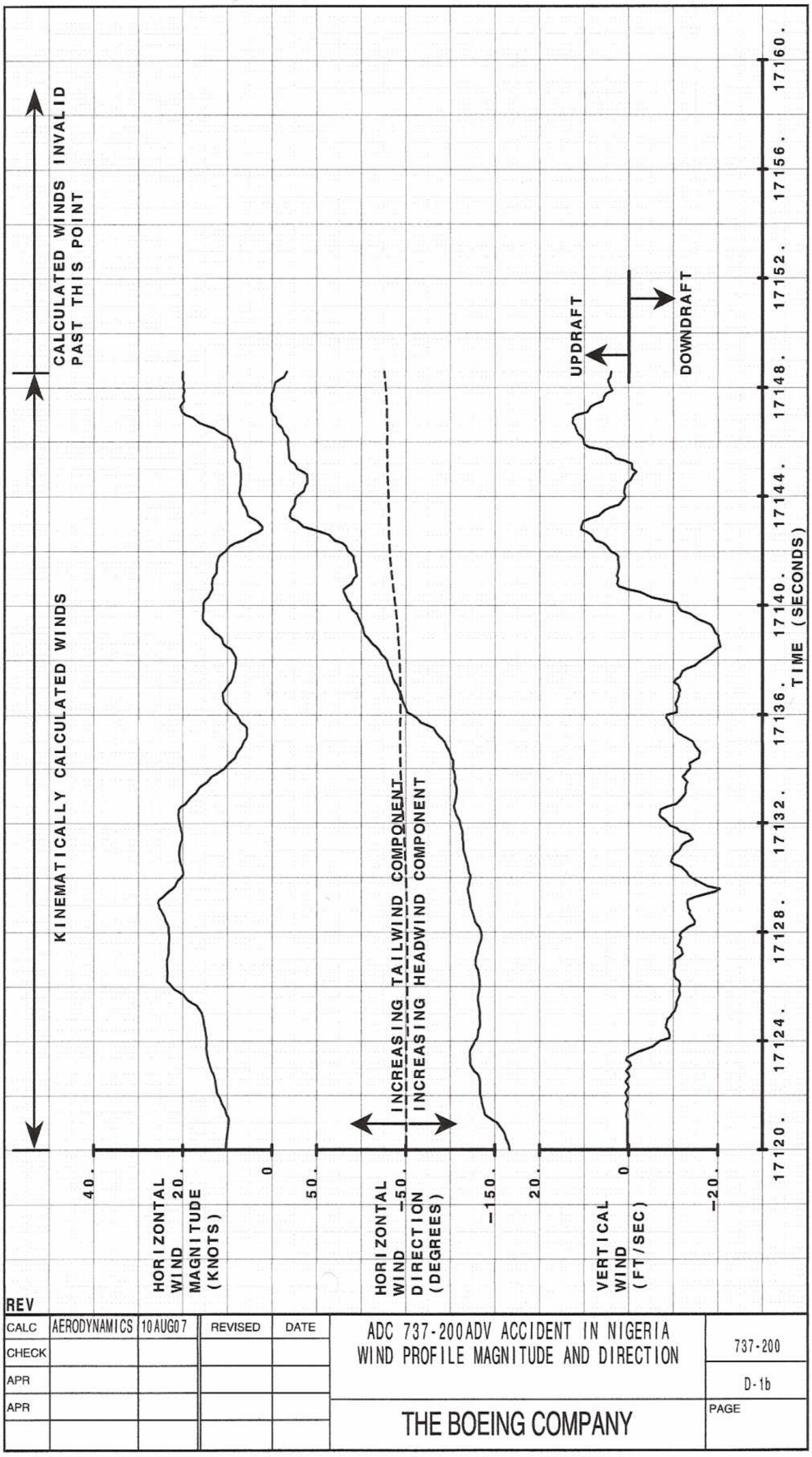


Fig 2-11 FDR data showing wind profile magnitude and direction

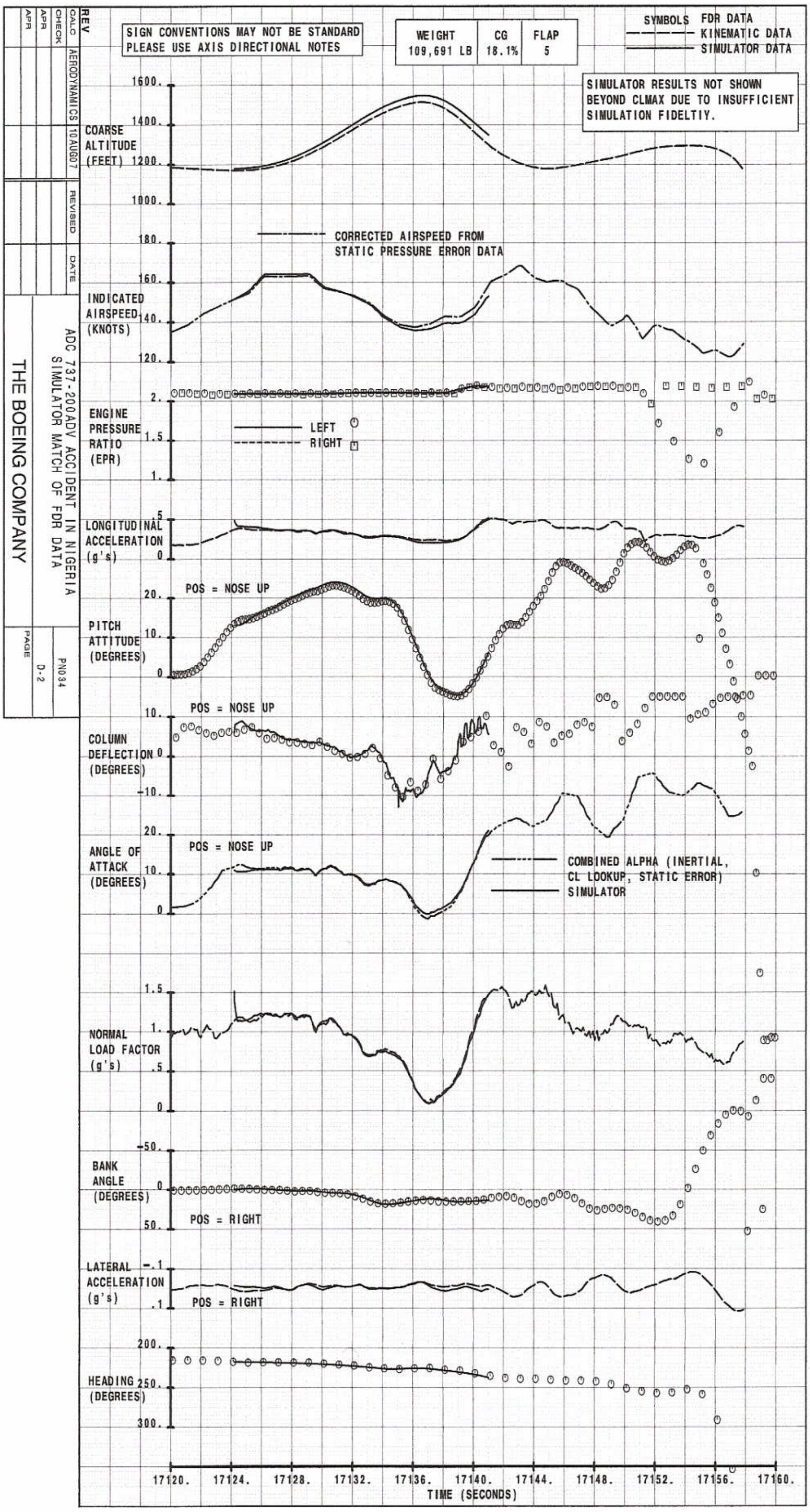


Fig 2-12 Simulator match of FDR data

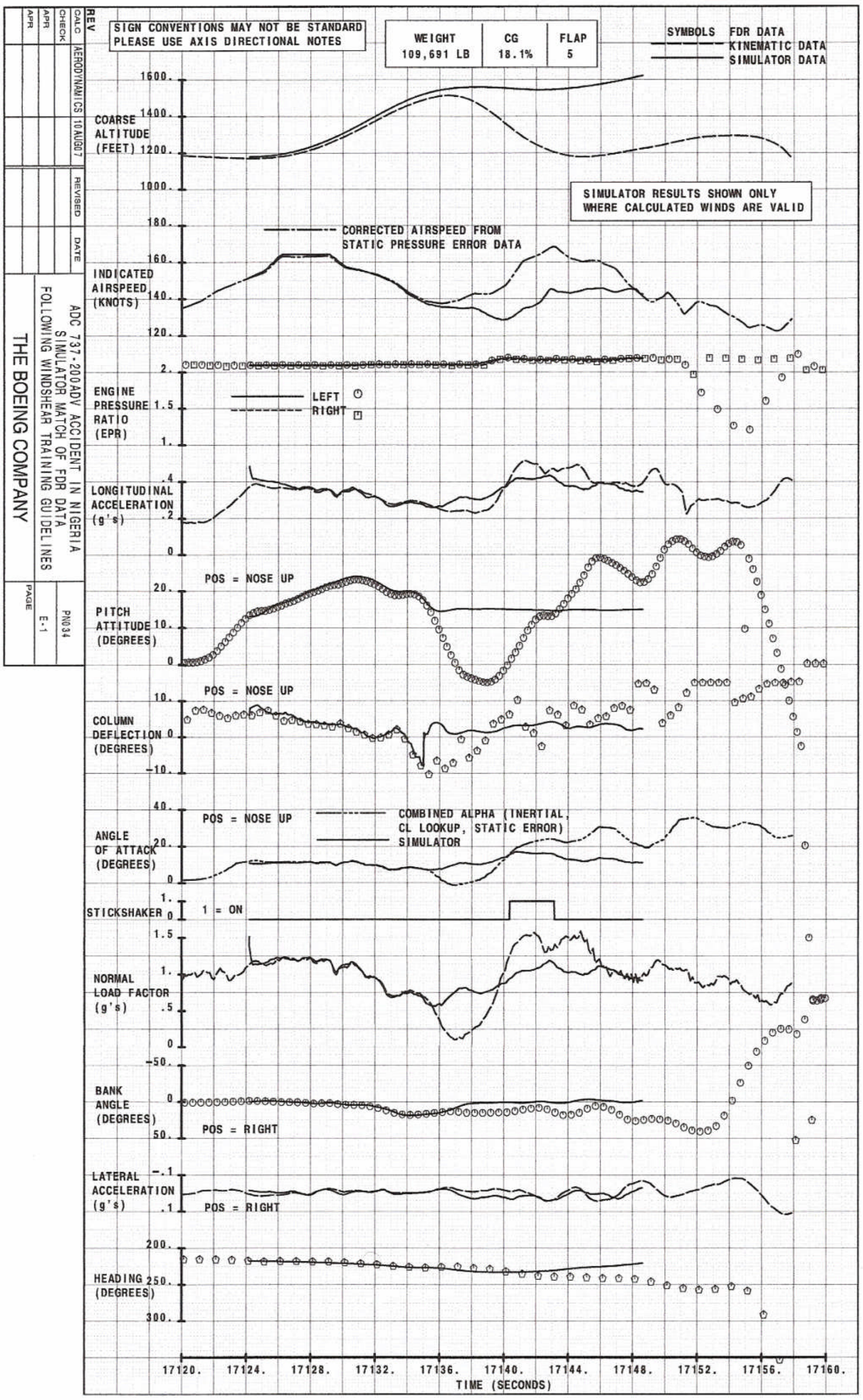


Fig 2-13 Simulator match of FDR data following windshear training guidelines

Although, bad weather created the situation, which the pilots reacted to, their reaction was not in accordance with windshear recovery procedure. The simulator training the crew undertook at Sabena Flight Academy in Brussels, Belgium did not adequately prepare them to handle the situation they found themselves even though the aircraft appeared to have enough energy to fly through the adverse weather condition. The simulator used for the training did not have the same facilities as the actual aircraft.

Windshear recognition and recovery was not part of the simulator training the First Officer received. However, the Captain received windshear training but it was inappropriate as the simulator was not a replica of the actual aircraft. Throughout the emergency period (from the first windshear warning to the ground impact) the responses from the pilot-not-flying was not in conformity with the windshear recovery procedures.

For detailed Boeing FDR Performance Analysis, see Appendix A.

2.4 Meteorological Information

AIB requested for a meteorological summary from the Boeing Company's Atmospheric Sciences Department. No ground station information for Nigeria was publicly available; the analysis is based on available satellite weather imagery. This data shows that only scattered low-top cumulus and insignificant cloud development was seen between 09:30 and 09:45 UTC. However, explosive convective development commenced sometime between 09:45 and 11:00 UTC. Conditions evolved from scattered low-top cumulus to an isolated convective cell with estimated tops to above 45000ft in just over an hour. Between 11:00 UTC and 11:30 UTC, the cell continued to intensify with estimated tops increasing to above 50000ft, while anchored over Abuja (little or no horizontal motion detected). Cloud top temperatures evolved from -77^{0}C between 11:00 UTC and 11:30 UTC.

The accident occurred in day light and in rain.
(See fig. 2-14 to fig. 2-16).

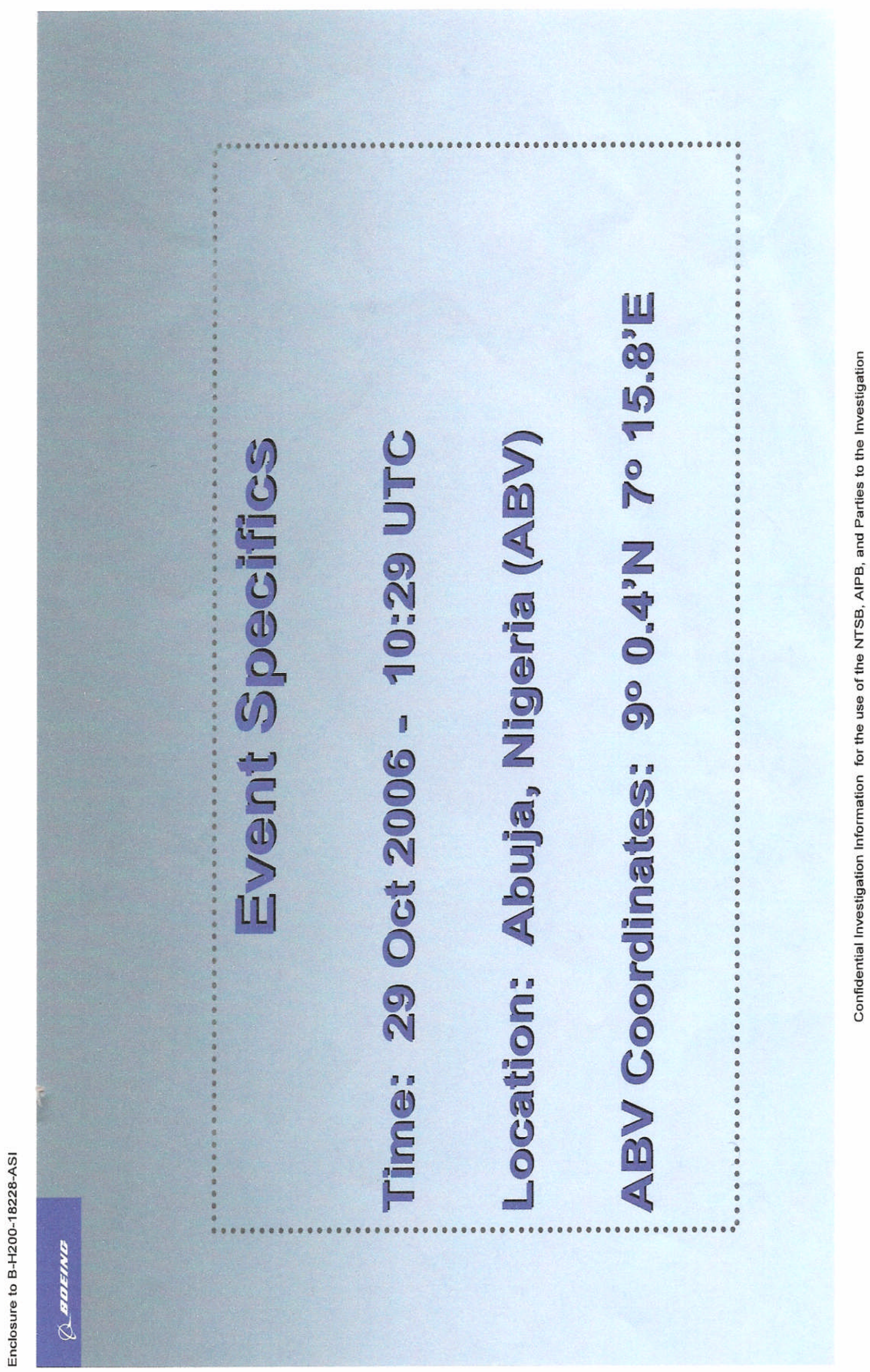


Fig 2-14 Abuja coordinates of crash site

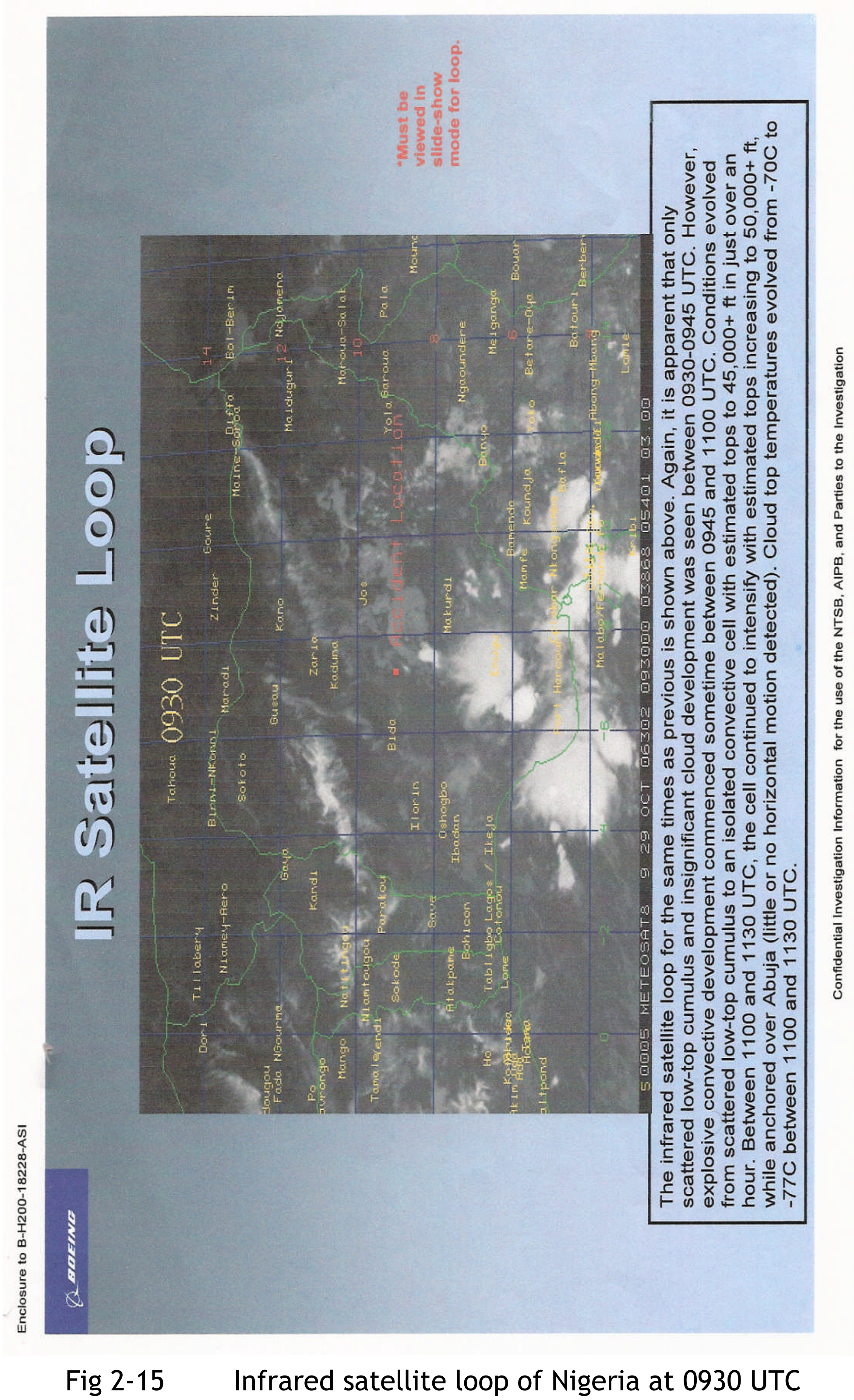


Fig 2-15 Infrared satellite loop of Nigeria at 0930 UTC (1030 hours local)

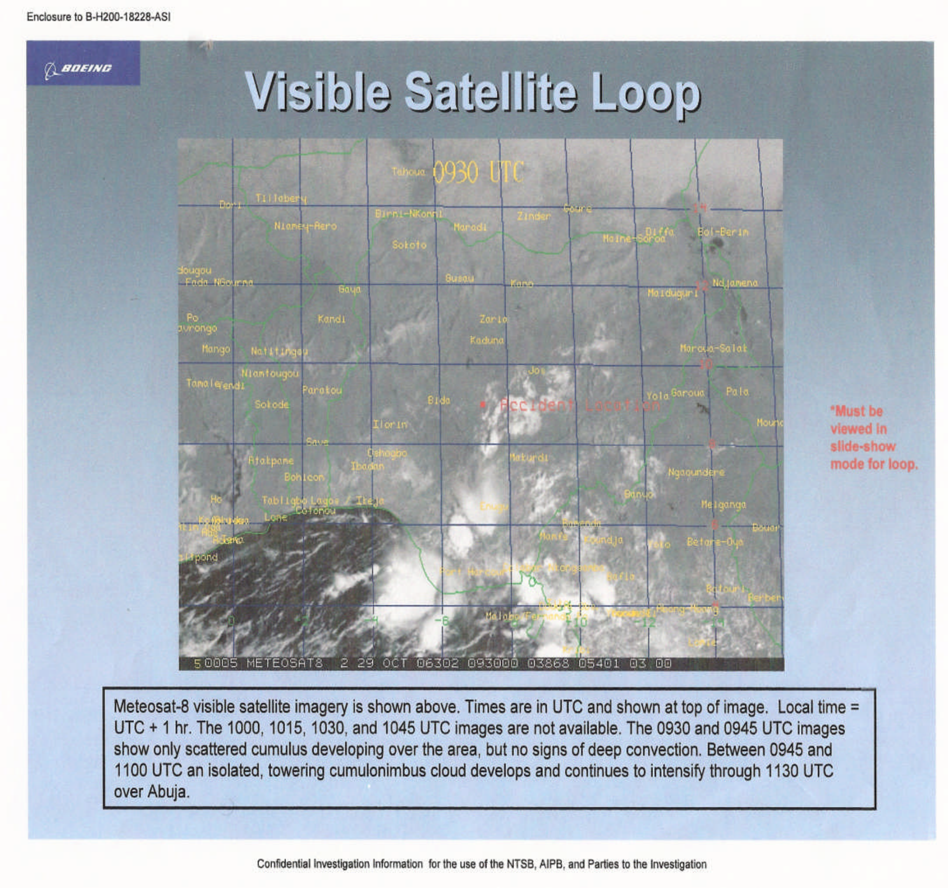


Fig 2-16 Visible satellite loop of Nigeria at 0930 hours UTC

The above satellite weather imagery confirmed the specific weather and the trend issued by Nigerian Meteorological Agency (NIMET) that prevailed at the airport between 1125hrs and 1200hrs.

When the pilot was given taxi clearance at 11:21hrs to holding position of runway 22, the pilot requested for wind check which was given as 210 degrees variable at 8kts. Shortly after, the wind was again transmitted to be South-westerly at 15kts with gusty wind. The wind was reported to be 35kts with a downward trend to 28kts within 1 minute. It was important to note that the captain of the Virgin Nigeria 042 on ground said “It looks like 35kts to me”. He continued by saying he was going to wait for an improvement in the weather. At this point the ADK 053 crew requested for take-off clearance, which was granted with a right turn-out on course.

From the weather report and the prevailing gusty wind, the trend would have required the crew to delay their departure, taking best practice and good airmanship into consideration, as avoidance was the best option when windshear was expected while still on ground. This brings to the fore the ability of an individual to make a decision to go or not to go.

As long as the weather condition was within the operational limit, the decision to take-off rested with the captain or pilot-in-command (PIC). The quality of decision is a reflection on the ability of the individual making the decision. The recognition and ability to translate the gusty trend is a sign of good and quality airmanship.

Radar

The ATC radar was off the air at the time of the accident. This could have aided in detecting the crash site early and enhance search and rescue and probably save more lives.

2.5 Windshear Weather

Wind variations at low-altitude have long been recognized as serious hazard to airplanes during takeoff and approach. These wind variations can result from a large variety of meteorological conditions such as: topographical conditions, temperature inversions, sea breezes, frontal systems, strong surface winds, and the most violent forms of wind change like in thunderstorm and rain showers.

2.5.1 Definition of Terms

(i) **Windshear** - *Any rapid change in wind direction and velocity.*

(ii) **Severe Windshear** – *A rapid change in wind direction and velocity causing airspeed changes greater than 15kts or vertical speed changes greater than 500ft per minute.*

(iii) ***Increasing Headwind Shear*** *– Windshear in which headwind increases causing an airspeed increase.*

(iv) ***Decreasing Headwind Shear*** *– Windshear in which headwind decreases causing an airspeed loss.*

(v) ***Decreasing Tailwind Shear*** *– Windshear in which tailwind decreases causing an airspeed increase.*

(vi) ***Increasing Tailwind Shear*** *– Windshear in which tailwind increases causing an airspeed loss.*

2.5.2 Sources of Low Level Windshear

There are four common sources of low level windshear listed as follows:

(i) ***Frontal Windshear***

Like so many things in weather, there is no absolute rule, but there are a couple of clues:

(1) The temperature difference across the Fronts at the surface is 10 degrees Fahrenheit (-12 degrees Celsius) or more; and

(2) The Fronts is moving at a speed of at least 30kts. The presence of these two factors especially during weather briefing could indicate the possibility of frontal wind shear.

(ii) ***Thunderstorm***

The gusty winds are associated with mature thunderstorms and they result in downdrafts striking the ground and spreading out horizontally. These winds can change direction by as much as 180º and reach velocities of 100kts as far as 10 miles ahead of the storm. The gust wind speed may increase as much as 50 percent between the surface and 1500ft, with most of the increase occurring in the first 150ft. While the other wind problem "the downburst," is also downdraft related, it is an extremely intense localized downdraft from a thunderstorm. This downdraft can exceed 720ft per minute vertical velocity at 300ft AGL. The power of the downburst can actually exceed aircraft climb capabilities, not only those of light aircraft but even of a high performance Air Force jet.

(iii) ***Temperature Inversions***

Overnight cooling creates a temperature inversion a few hundred feet above the ground. This, coupled with high winds from what is known as the low level jet, can produce significant wind shears close to the ground. One aspect of temperature inversion shears is that as the inversion dissipates the shear plane and gusty winds move closer to the ground.

(iv) ***Surface Obstructions***

The sudden change in wind velocity can seriously affect a landing due to construction of large hangers or other buildings near the runway. Some airfields are close to mountain ranges, and there are mountain passes close to the final approach paths. Strong surface winds blowing through these passes can cause serious localized wind shears during the approach. The real problem with such shear is that it is almost totally unpredictable in terms of magnitude of severity. A pilot can expect such shears whenever strong surface winds are present.

2.5.3 Types of Windshear

The following types of Wind shear exist:

(i) ***Vertical Windshear***

Vertical variations of the horizontal wind component, resulting in turbulence and affecting aircraft airspeed when climbing or descending through the shear layer.

(ii) ***Horizontal Windshear***

Horizontal variations of the wind component (e.g. decreasing head wind or increasing tail wind, or a shift from a head wind to a tail wind), affecting the aircraft in level flight, climb or descent.

2.5.4 Avoidance

The following information can be used to avoid areas of potential wind shear:

- ***Weather Reports and Forecasts***

The Low-Level Windshear Alert System (LLWAS) is used by controllers to warn pilots of existing or impending wind shear conditions.

Terminal Doppler Weather Radar (TDWR) detects approaching windshear areas and thus provides pilots with an advance warning of wind shear hazard.

- ***Pilot Reports***

Pilot Reports (PIREPS) of windshear causing airspeed fluctuations in excess of 20kts or vertical-speed changes in excess of 500ft per minute (fpm) below 1000ft above airport elevation should be cause for caution.

- ***Visual Observation***

Blowing dust, rings of dust, dust devils (i.e. whirlwinds containing dust or sand) and any other evidence of strong local air outflow near the surface often are indications of windshear.

- ***Onboard Wind-component and Groundspeed Monitoring***

On approach, a comparison of the head-wind component or tail-wind component aloft (as available) and the surface head-wind component or tail-wind component indicates the likely degree of vertical wind shear.

- *Onboard weather radar and*

- *Onboard predictive windshear system.*

2.5.5 Detection and Prediction Recognition

Timely recognition of windshear is vital for successful implementation of a windshear recovery procedure. The following are indications of a suspected windshear condition:

- *Indicated airspeed variations in excess of 15kts.*

- *Groundspeed variations (decreasing head wind or increasing tail wind, or a shift from head wind to tail wind).*

- *Vertical-speed excursions of 500fpm or more.*

- *Pitch attitude excursions of five degrees or more.*

- *Glide slope deviation of one dot or more.*

- *Heading variations of 10 degrees or more and*

- *Unusual auto throttle activity or throttle lever position.*

2.5.6 Reactive/Predictive Warnings

The windshear warning and flight director (FD) recovery guidance are referred to as a reactive windshear system, which does not incorporate any forward-looking (anticipation) capability.

To complement the reactive windshear system and provide an early warning of windshear activity, some weather radars detect windshear areas ahead of the aircraft (typically providing a one-minute advance warning) and generate a windshear warning (red "WIND SHEAR AHEAD"), caution (amber "WIND SHEAR AHEAD") or advisory alert messages. This equipment is referred to as a predictive windshear system.

2.5.7 Aircraft Performance and Operations

Training

There was an operational requirement for pilots to be trained to counter the effects of low level wind shear and turbulence. Training on the windshear recovery procedure should be conducted in a full-flight simulator, using windshear profiles recorded during actual windshear encounters.

Operating Procedures

The following opportunities are available to enhance windshear awareness and operating procedures:

Standard Operating Procedures (SOPs)

The Standard Operating Procedures (SOPs) should emphasize the following windshear awareness items:

- ***Windshear Awareness and Avoidance***

  - *Approach briefing and*

  - *Approach hazards awareness.*

- ***Windshear Recognition***

  Task-sharing for effective cross-check and backup.

  Particularly for excessive parameter deviations.

  Energy management during approach.

- ***Windshear Recovery Procedure***

  Readiness and commitment to respond to a windshear warning.

2.5.8 Departure Briefing

The takeoff-and-departure briefing should include the following windshear awareness items:

- ***Assessment of the conditions for a safe takeoff based on**:*

- *Most recent weather reports and forecasts.*
- *Visual observations.*
- *Crew experience with the airport environment and the prevailing weather conditions.*
- *Consideration to delaying the takeoff until conditions improves.*

2.5.9 Takeoff and Initial Climb

If windshear conditions are expected, the crew should:

- *Select the most favourable runway, considering the location of the likely wind shear/downburst condition.*
- *Select the minimum flaps configuration compatible with takeoff requirements to maximize the climb-gradient capability.*
- *Use the weather radar (or the predictive wind shear system, if available) before beginning the takeoff to ensure that the flight path is clear of hazards.*
- *Select maximum takeoff thrust.*
- *After selecting the takeoff/go-around (TOGA) mode, select the flight-path-vector display for the Pilot Not Flying (PNF) as available, to obtain a visual reference of the climb flight path angle and*

- *Closely monitor the airspeed and airspeed trend during the takeoff roll to detect any evidence of impending windshear.*

2.5.10 Recovery

- *Avoid large thrust variations or trim changes in response to sudden airspeed variations.*

- *If a windshear warning occurs, follow the flight director windshear recovery pitch guidance or apply the recommended escape procedure and*

- *Make maximum use of aircraft equipment, such as the flight-path vector (as available).*

Source: What every pilot and Accident Investigator should know about airplanes by Arthur Torosian.

2.6 Flight Data Recorder and the Cockpit Voice Recorder

The FDR and CVR were recovered in good condition and sent out to the National Transport Safety Board (NTSB) facilities in the United States of America for decoding and auditioning. The FDR did not show any evidence that the aircraft had any form of technical problem, while the CVR recorded a lot of activities. From the CVR, it was evident that there was a windshear. The cockpit windshear alarm was clearly recorded. The action of the pilot on windshear before take-off was also clearly recorded. The Virgin Nigeria 042 captain's observation that suggested the wind gusting 35kts was also clearly recorded. The voice of the first officer's reaction to the situation was also clearly recorded.

2.7 Operator's Policies

The policy on low experience stated that "Crew with less than 1000 hours experience in operating are deemed to be low in flying experience on type". The captain had 353:15 hours on Command and 8545 hours total flying hours as at 27th September, 2006. The first officer had 6490 flying hours and graded "within limit" in his last simulator report.

The airline had no policy on operation in adverse and potentially hazardous atmospheric condition. This section was left blank in their Operations Manual which was approved by the Regulatory Authority. This could have guided the pilots on the decision to go or not to go in adverse and potentially hazardous atmospheric conditions.

2.8 Personnel

The training programme that was used during the captain's upgrade was not in accordance with the airline's Operations/Training Manual. There was inconsistency in the method of assessment by the Instructor. The grading was not consistent with the airline's training documents.

Between the 3rd and the 8th of September, 2005 the aircraft type rating conversion course in SABENA Flight Academy, Brussels were as follows:

Date	Hours	Grade
03-09-05	2 hours	A = Good
04-09-05	2 hours	A = Good
04-09-05	2 hours	R= Average
05-09-05	2 hours	R= Average
06-09-05	2 hours	R= Average
07-09-05	2 hours	R= Average
08-09-05	2 hours	R= Average

From the above simulator report it could be seen that the captain was an average pilot.

Another indicator was that the captain had well over 7873 flying hours before taking command. Most airlines give command between 3000 and 4000 hours depending on the airline's policy, type of aircraft and the ability of the individual pilot.

The first officer's record of experience showed a lot of discrepancies. He was operating in Nigeria with a Nigerian Commercial Pilot Licence (CPL). The Regulatory Authority granted him a Nigerian Airline Transport Pilot Licence (ATPL) based on an ATPL issued to him by Guinea Civil Aviation Authority. The existence of an approved aviation training organization in Guinea with the capability to train pilots to ATPL level could not be established due to uncooperative attitude of the Guinean Authority. There were inconsistencies in his hour logs. The last simulator training on the 10th of September, 2006 in SABENA Flight Academy as indicated by the simulator instructor is as follows:

Session A	L = within limit
Session B	Quite fair

The grading was not consistent with the airline's simulator recurrent training document. "Quite fair" was not part of the grading in the airline's document. Below were the airlines' grading codes:

A = Good

R = Average

L = Within limit

U = Unsatisfactory

The first officer had 6490 flying hours and graded "within limit" in his last simulator report.

The following were the inconsistencies in the hour log of the first officer:

Date	Hours	Crew licencing file Page
23-10-80	304	Page 2
01-04-81	310.1	Page 13
30-11-82	367.2	Page 25
01-02-88	551	Page 32
24-12-90	432	Page 41*
21-02-91	761.56	Page 54
16-04-93	1680	Page 61
04-10-94	2290	Page 69
19-08-96	3310	Page 75
14-04-98	2900	Page 84*
29-06-99	3500	Page 88
01-09-2000	2877.40	Page 93*
18-12-01	3070.20	Page 100*
01-07-02	3255.20	Page 105*
29-01-03	3754.04	Page 111
25-08-03	4403.39	Page 116
12-07-04	4810.59	Page 126
04-01-05	5158.10	Page 132
31-08-05	5487.40	Page 138
14-03-06	5981.50	Page 144
13-09-06	6447.05	Page 163
29-09-06	6497.50	Page 168

* *shows where the flying hours decreased instead of increasing*

2.9 Regulatory Authority

Based on the extracts above from the crew licencing files, the inconsistencies in the flight hours log would have been detected by the Regulatory Authority during licence renewals.

The Authority was aware that only one instructor conducted all the trainings, that is, simulator training and check ride, aircraft training and check ride. This practice did not permit check and balances, and standardization. One instructor should have done the simulator training while another performed the final check. The same for the aircraft training and check.

3.0 CONCLUSIONS

3.1 Findings

3.1.1 During the captain's upgrade, the simulator training was performed with only one instructor who also did the checks. The same instructor also conducted the captain's aircraft training and checks.

3.1.2 The NCAA document available to AIB indicated that the captain was an average pilot.

3.1.3 During the last two simulator trainings on the 14th of March, and the 19th of September, 2006, neither lessons A nor B included windshear training. However, the simulator check graded the captain as "good" in the check ride for the exercise.

3.1.4 The captain had 7870 hours before taking command.

3.1.5 From the records available, the First-Officer (F/O) was within limit in his last simulator training.

3.1.6 There were inconsistencies in the first officer's hour log.

3.1.7 The coordination of the responsibilities between the captain and the first officer was inconsistent with CRM procedures.

3.1.8 The first officer's licence renewal application forms were not properly completed.

3.1.9 The airplane was certified, maintained and equipped in accordance with existing regulations.

3.1.10 The Operations Manual which contained no text on flight in adverse and potentially hazardous atmospheric conditions was approved by the Regulatory Authority. (Section 8.3.8)

3.1.11 During the windshear recovery maneuver there were no standard call-out from the pilot-not-flying (First Officer).

3.1.12 The ATC radar was off the air for maintenance which made tracking and detection of the aircraft difficult during the search and rescue operations.

3.1.13 Abuja airport had only one wind sensor remotely located (behind the control tower) from the runways.

3.1.14 While at the holding point, before take-off, the captain mentioned to the first officer that they should be ready for windshear.

3.1.15 The flight simulator training facility available to the airline, though approved by the Regulatory Authority, was inappropriate for windshear training on type because it did not have the capability for simulating windshear encounter.

3.1.16 The first officer obtained his airline transport pilot licence from Guinea Civil Aviation Authority. All efforts to clarify certain issues associated with this licence proved unsuccessful due to lack of cooperation by the Guinean Authority.

3.1.17 Crew licences obtained from ICAO contracting states were accepted by the Regulatory Authority and converted to Nigerian licences without verifying and confirming the capabilities of the training organization.

3.1.18 The company did not establish Standard Operating Procedures for conducting flight operations in adverse and potentially hazardous atmospheric conditions as required by existing regulation. However the Regulatory Authority approved the manual, which did not contain the detailed procedures of operations in adverse and potential hazardous atmospheric conditions.

3.1.19 The aircraft was found to be serviceable and airworthy.

3.1.20 NCAA did not detect the discrepancies in the pilot hour log and improperly completed licence renewal forms.

3.1.21 The analysis of the FDR data indicated that the airplane entered into a headwind –shift-to-tailwind windshear shortly after liftoff, which significantly affected the aerodynamic performance of the airplane.

3.1.22 The Pilot Flying responded to the windshear by adding a small amount of power and by pulling back on the control column causing a significant pitch attitude change.

3.1.23 The Pilot-not-flying responded to the windshear by calling for the Pilot Flying to pull up.

3.1.24 The airplane entered into a full aerodynamic stall followed by a roll to the left of over 90 degrees and steep descent into the ground.

3.1.25 The aircraft was pitched to an attitude that resulted in the temporary disruption of airflow to and momentary loss of power in both engines.

3.1.26 The flight crew inadequately evaluated the weather by their failure to recognize the severity of the windshear condition and the effect on aircraft performance.

3.1.27 Windshear conditions prevailed at the time of the accident.

3.2 Causal Factor

The pilot's decision to take-off in known adverse weather conditions and failure to execute the proper windshear recovery procedure resulted in operating the aircraft outside the safe flight regime, causing the aircraft to stall very close to the ground from which recovery was not possible.

3.3 Contributory Factors

(1) Inability of the flight crew to apply windshear recovery procedures and the use of inappropriate equipment for windshear recovery procedure during simulator recurrrecncy. Lack of company Standard Operating Procedures (SOP) for flight operations in adverse weather conditions.

(2) The coordination of responsibilities between the pilot-flying (PF) and pilot not flying(PNF) during their encounter with adverse weather situation was inconsistent with Standard Operating Procedures (SOP) for the duties of the pilot-flying (PF) and pilot not flying(PNF) resulting in the inadequate control of the aircraft.

4.0 SAFETY RECOMMENDATIONS

4.1 Safety Recommendations 2010 – 005

NCAA should ensure adequate oversight on:

(a) Adverse Weather/Windshear recognition and recovery maneuvers as a compulsory part of the initial and recurrent simulator training of flight crew.

(b) That the simulator used for training should be a replica of the aircraft.

4.2 Safety Recommendations 2010 – 006

(a) NCAA should ensure that same instructor does not conduct any training and at the same time be the check airman.

(b) NCAA should increase the monitoring of the quality and content of flight crew trainings.

4.3 Safety Recommendations 2010 - 007

NCAA should ensure that NIMET expedite actions on the completion of the on-going installation of low level windshear alert systems (LLWAS) at all airports to enhance the quality of weather information obtained.

4.4 Safety Recommendations 2010 - 008

NCAA should ensure that Operators Operations Manual/Standard Operating Procedures (SOP), which guides the crew decisions in times of adverse weather and potentially hazardous atmospheric conditions, be designed to be explicit to the crew before such manuals are approved.

4.5 Safety Recommendations 2010 – 009

NCAA should ensure improvement in the procedure for screening and authentication of foreign licenses of personnel before such licenses are re-validated. Training organizations should also be verified and approved by the Authority.

APPENDIX A
BOEING FDR PERFORMANCE ANALYSIS

Enclosure to 66-ZB-H200-ASI-18292

Boeing FDR Performance Analysis, ADC 737-200 5N-BFK Accident in Abuja, Nigeria – 29 October 2006

A) FDR Data Analysis Flight Summary

Figure A-1 shows the pertinent FDR data for the accident flight. The FDR installed on the accident airplane recorded a total of 18 parameters. Of these 18 available parameters, 14 of them were converted into usable engineering units as listed on Figure F-1. Four other parameters were available in the FDR data. However, Boeing was unable to convert these parameters into usable engineering units.

Pertinent information such as vane angle of attack, ground speed, and drift angle were not available in the data set. The sign conventions were validated through the use of previous-flight maneuvers existing in the FDR data frame.

The FDR data for the accident flight (Figure A-1) show the aircraft departed on a heading of approximately 220 degrees. Rotation was initiated at approximately 133 knots. Reference (b) shows V_1 to be 136 knots, V_R to be 138 knots, and V_2 to be 143 knots for this aircraft configuration as provided by the AIB. After liftoff, the airspeed appears to have briefly leveled off at 162 knots, before quickly decreasing. At time 17133 seconds, the column was commanded airplane-nose-down, causing the airspeed to recover, but with a corresponding reduction in pitch attitude (to ~ -5 degrees) and rate of climb. After 4 seconds, the column was commanded airplane-nose-up. The altitude data become erratic beyond this point, due to the very high angle of attack of the aircraft during this time. After time 17150.7 seconds, the left and right Engine Pressure Ratio (EPR) values decrease, with the right engine recovering shortly afterwards and the left engine 4 seconds behind. The FDR data end during time 17159 seconds, presumably near the time of initial impact. The heading change to the right seen at time 17154 seconds appears to be incorrect. This heading error most likely resulted from a vertical gyro gimbal error inherent in older heading indicators during large bank angle maneuvers. The abrupt heading, pitch and bank angle changes recorded at time 17157 seconds most likely resulted from vertical gyro gimbal-lock when the aircraft exceeded a roll attitude of 90 degrees.

B) Flight Path Reconstruction

The translational accelerations (Nx - longitudinal, Ny - lateral, and Nz - vertical) recorded in the FDR data were integrated to calculate the aircraft's ground speed, altitude, and ground track relative to the airport runway. This information is needed to determine the aircraft angle of attack and in the determination of the winds. The recorded data originates from a single, three-axis accelerometer located along the rear spar of the wing in the main landing gear wheel well. These units have bias errors which must be factored into the integration to produce airplane position. These translational acceleration biases were determined in the following manner.

The Nz bias was adjusted until 1) the integrated altitude closely matched the initial altitude profile recorded in the FDR data and 2) the final altitude matched the impact site altitude. The pressure altitude recorded in the FDR data shows erratic behavior after time 17140 seconds. This behavior is due to known limitations in production aircraft air data systems when the airplane is at high angles of attack; correction factors must be applied based on flight test data. An Nz bias of 0.0251g produced the best altitude match within these constraints.

The Nx bias was determined by closely matching the integrated Nz acceleration to the estimated ground speed (shown in Figure B-2) and by targeting the endpoint to match the impact site location longitudinal displacement from the beginning of the takeoff roll (gsz). By following these constraints, an Nz bias of 0.06g was chosen.

The constraints used in the calculation of the lateral acceleration (Ny) bias included targeting the endpoint to match the impact site location lateral displacement from the runway centerline (gsy). This bias was also chosen so that the aircraft lined up with the centerline of the runway during the initial takeoff roll. The Ny bias chosen was -0.005g.

Integrating the accelerations with these three biases resulted in the altitude profile shown in Figure B-3 and the ground track profile shown in Figure B-4. Figure B-4 shows the aircraft just after it made a left hand turn onto Runway 22. The location of the final FDR data point is shown as 2471 feet to the right of the runway centerline and 13034.5 feet from the beginning of Runway 22. It is assumed that the final FDR data point occurred at impact. However, the final FDR data point is approximately 100 feet off in each direction from the measured distance provided by the investigation. This represents the best fit of the data set and falls within the data accuracy. The acceleration biases above are consistent and reasonable based on previous experience with FDR data.

C) Determination of Angle of Attack (alpha)

It was vital to determine an estimate for angle of attack in order to determine the wind profile for this accident. The FDR data set did not record the vane angle so alternate derivation methods were required. Several different methods were needed since no single method provided valid data throughout the entire event maneuver. Each of the methods used is described below.

Inertial Angle of Attack

The inertial angle of attack was calculated by subtracting the flight path angle of the aircraft (gamma) from the pitch attitude of the aircraft (theta). The results are shown in Figure C-1. A limitation to this method is that it is not valid in the presence of vertical winds.

Lift Coefficient Lookup Method

The FDR acceleration data (with the above acceleration biases applied) were used to calculate the lift coefficient of the aircraft for the time history provided. Simulator lift tables were used to back out an angle of attack for each calculated lift coefficient value. This method is valid only for the portion of the lift coefficient curve up to the maximum lift coefficient (C_{Lmax}). Maximum lift coefficient occurs at approximately 24.0 degrees angle of attack (flaps 5) so other methods are required for higher alphas. In addition, the lift coefficient calculated from the FDR data is not valid while the aircraft is on the ground. Therefore, this method is only valid between liftoff and C_{Lmax}. The results are shown in Figure C-2.

Static Pressure Error Method

Flight tests have shown that indicated altitude and airspeed become erroneous during high angle of attack maneuvers similar to those experienced in this accident. This behavior is due to known limitations in production aircraft air data systems. The error is attributed to air flow changes at the pitot-static probes. Corrections must be made to the FDR data to have a correct altitude and airspeed measurement. Boeing has developed error correction charts for both altitude and airspeed based on angle of attack.

The difference between the Nz integrated altitude (reference figure B-3) and the erroneous altitude from FDR data will give the pressure altitude error. This error can be used in to determine an estimate of angle of attack in those regions where a static pressure error exists. This is shown on Figure C-3.

Resulting Angle of Attack Profile
By combining the three methods described above (Inertial, Lift Coefficient Lookup, and Static Pressure Error) in the respective areas that they are valid, a reasonable estimate for angle of attack was determined. The inertial angle of attack is not valid in the presence of vertical winds and therefore, in this application, is used only when the aircraft is on the ground. The angle of attack that was determined from the lift coefficient lookup method is not valid in the stall region, and therefore is used from liftoff to the beginning of stall. The angle of attack determined from the static pressure error method is used where it is valid, in the high angle of attack, stall region. The results of the integration of the three angle of attack calculation methods for this event can be seen in Figure C-4.

D) Determination of Wind Profile
The combined angle of attack was then used to determine the magnitude and direction of the winds acting on the aircraft during takeoff. Using the biased acceleration data determined above, the resulting body axis inertial speeds were integrated (u, v, w). The body axis airspeeds were then calculated based on the derived true airspeed, the calculated angle-of-attack and a calculated sideslip angle based on the simulator sideforce model. The calculated body wind speed is the difference between the calculated body axis inertial speeds and the body axis airspeeds. These are then converted into the horizontal (magnitude and direction) and the vertical winds by using Euler transformations. The resulting winds are shown in Figures D-1a and D-1b. Figure D-1a displays the winds relative to the runway heading and Figure D-1b display the winds in a magnitude and direction format. These calculation methods did not prove to be reliable in the high angle of attack, large bank angle region. Therefore, the winds were not calculated in that region.

Simulator Results
An engineering simulation analysis was conducted to validate the calculated wind profile with the FDR data. Aircraft initial conditions such as weight, center of gravity, stabilizer, and flaps were set to the reported aircraft positions. The updated altitude profile, corrected airspeed, and the biased accelerations were used for the simulator match.

For this analysis, mathematical pilot models were used to calculate the column required to match the FDR pitch attitude and to calculate the wheel required to match the FDR roll attitude. The calculated winds were then read into the simulator and a match of the FDR data was performed. The calculated winds provided a good match of the data for low-alpha segment of the match. Beyond CL_{max}, the simulator cannot be used to successfully match the data. This is due to insufficient simulation fidelity in the high angle of attack region. The final match of the FDR data is shown in Figure D-2.

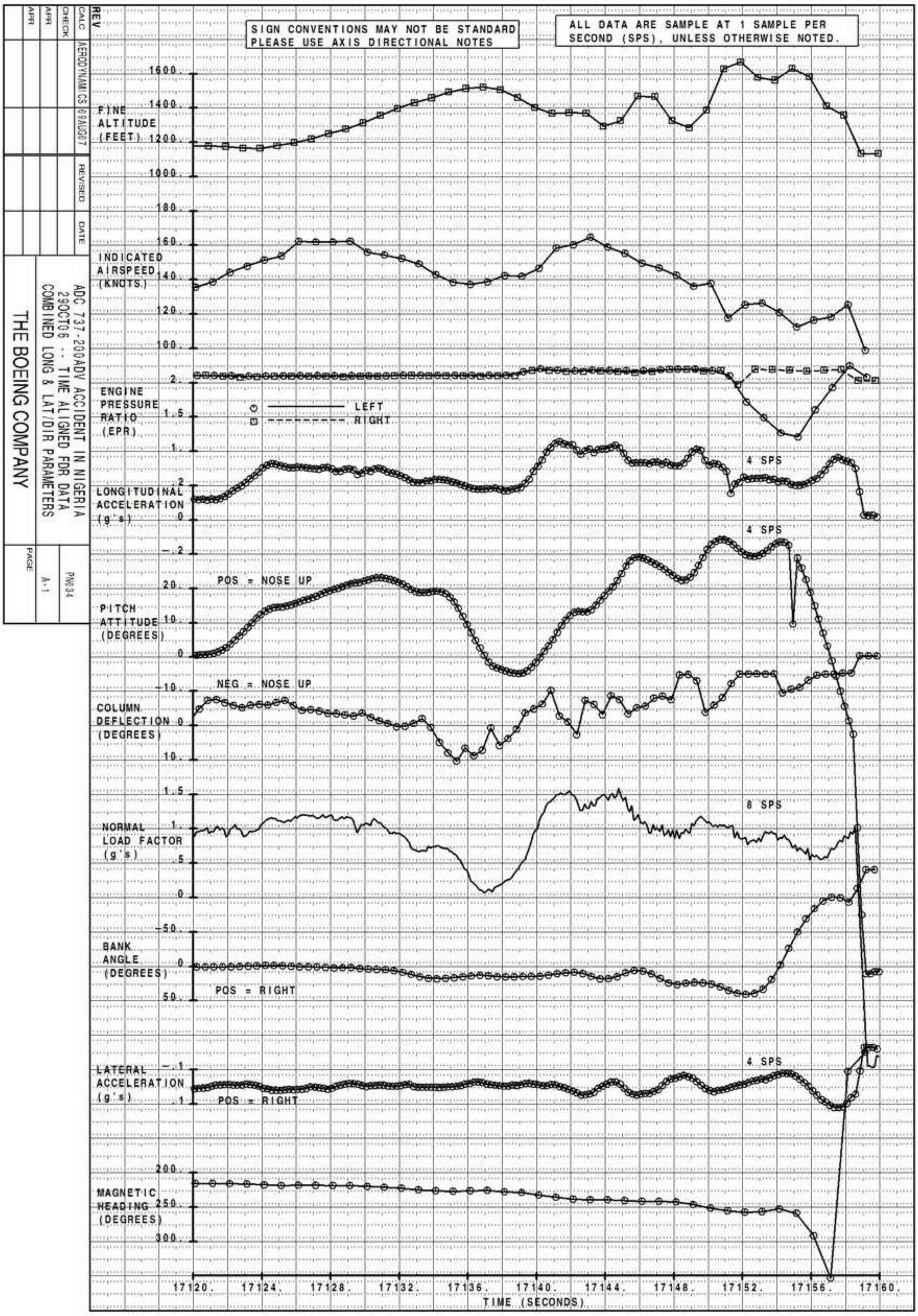
In order to obtain this match of the accident data, biases on the total aerodynamic drag coefficient (C_D) and the total aerodynamic lift coefficient (C_L) were introduced. A constant C_D bias of -0.025 was added to the drag model and a constant C_L bias of -0.05 was added to the lift model to obtain a good match of the data.

Wind Profile
The wind profile (Figure D-1a) shows an increasing headwind as the aircraft was on the takeoff roll through rotation and liftoff. The headwind then quickly turns into an increasing tailwind contributing to a total airspeed loss of about 25 knots in 6 seconds. A vertical wind shear immediately appears as the aircraft lifts off from the runway. This profile is consistent with the characteristics of known windshear events. The downward acting vertical wind profile and the changing from headwind to a tailwind in the horizontal direction specific to this event are consistent with a windshear generated by local microburst activity.

E) Windshear Training Guidelines
Industry windshear guidance places emphasis on avoidance, precautions, and recovery. The reference (c) FCOM states under the area of windshear avoidance that "presence of windshear may be indicated by thunderstorm activity" among other items. To recover from a windshear encounter, both the Reference (b) training aid and (d) QRH recommend to aggressively apply maximum thrust and simultaneously roll wings level and rotate towards an initial pitch attitude of 15 degrees. Reference (d) also states that "in all cases, the pitch attitude that results in intermediate stick shaker or initial buffet is the upper pitch attitude limit." As related to this accident Reference (a) states "If the pilot attempts to regain lost airspeed by lowering the nose, the combination of decreasing airspeed and decreasing pitch attitude produces a high rate of descent. Unless this is countered by the pilot, a critical flight path control situation may develop very rapidly."

A simulator analysis was performed following the recommended windshear guidelines for the accident data to determine if it was possible to fly out of these winds. As the aircraft decelerated through a 15 knot loss in airspeed, the simulator controls were commanded to target a pitch attitude of 15 degrees until the aircraft flew out of the windshear. Figure E-1 shows the results of this simulation. Following the recommended windshear guidelines, the results show that the aircraft may have been able to successfully fly through the windshear.

F) Conclusions
On October 29, 2006, at 1029 UTC, an Aviation Development Company (ADC) 737-200ADV (PN034) registration 5N-BFK, impacted the ground shortly after takeoff from Runway 22 at the Nnamdi Azikiwe International airport in Abuja, Nigeria. The investigation provided the Flight Data Recorder (FDR) data to Boeing for analysis. The FDR installed on PN034 recorded a total of 18 parameters. Pertinent information such as vane angle of attack, ground speed, and drift angle were not available in the data set. Integration of FDR acceleration data, used in conjunction with simulator lift tables and a static error correction factor, provided a reasonable estimate of altitude and angle of attack, which were then used to calculate the winds. The analysis shows that a horizontal and vertical windshear were experienced by the aircraft during the takeoff. Subsequent control inputs resulted in aircraft aerodynamic stall leading to altitude loss and ground impact.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INDICATED AIRSPEED (KNOTS)
ENGINE PRESSURE RATIO (EPR)
LEFT
RIGHT
LONGITUDINAL ACCELERATION (g's)
4 SPS
PITCH ATTITUDE (DEGREES)
POS = NOSE UP
COLUMN DEFLECTION (DEGREES)
NEG = NOSE UP
NORMAL LOAD FACTOR (g's)
8 SPS
BANK ANGLE (DEGREES)
POS = RIGHT
LATERAL ACCELERATION (g's)
MAGNETIC HEADING (DEGREES)
TIME (SECONDS)
ADC 737-200ADV ACCIDENT IN NIGERIA
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COMBINED LONG & LAT/DIR PARAMETERS
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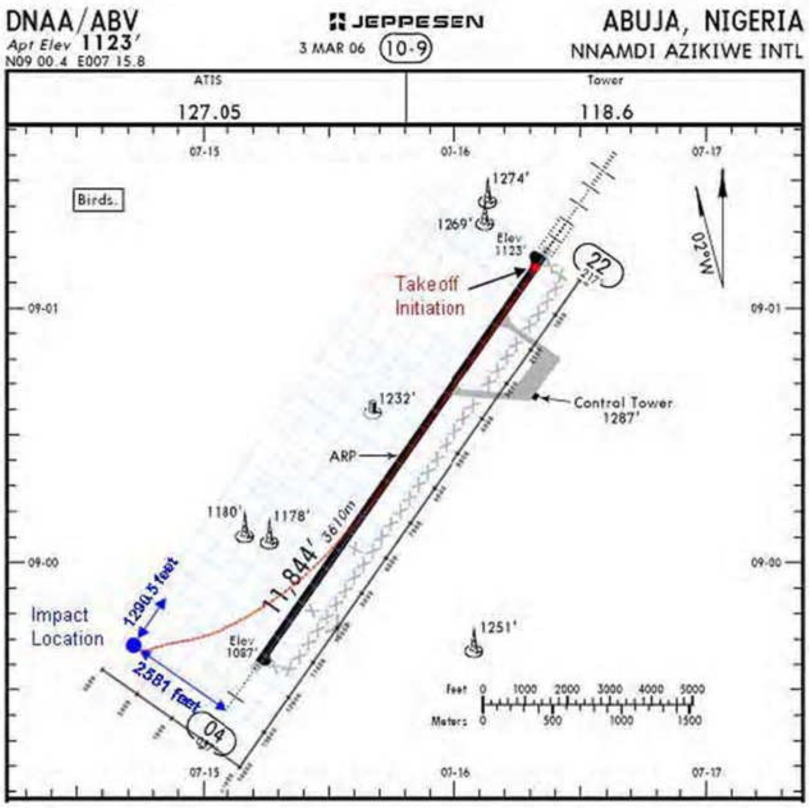
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JEPPESEN
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ABUJA, NIGERIA
NNAMDI AZIKIWE INTL
ATIS
127.05
Tower
118.6
Birds.
1274'
1269'
Elev 1123'
22
Takeoff Initiation
Control Tower 1287'
1232'
ARP
1180'
1178'
11,844' 3610m
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Feet 0 1000 2000 3000 4000 5000
Meters 0 500 1000 1500
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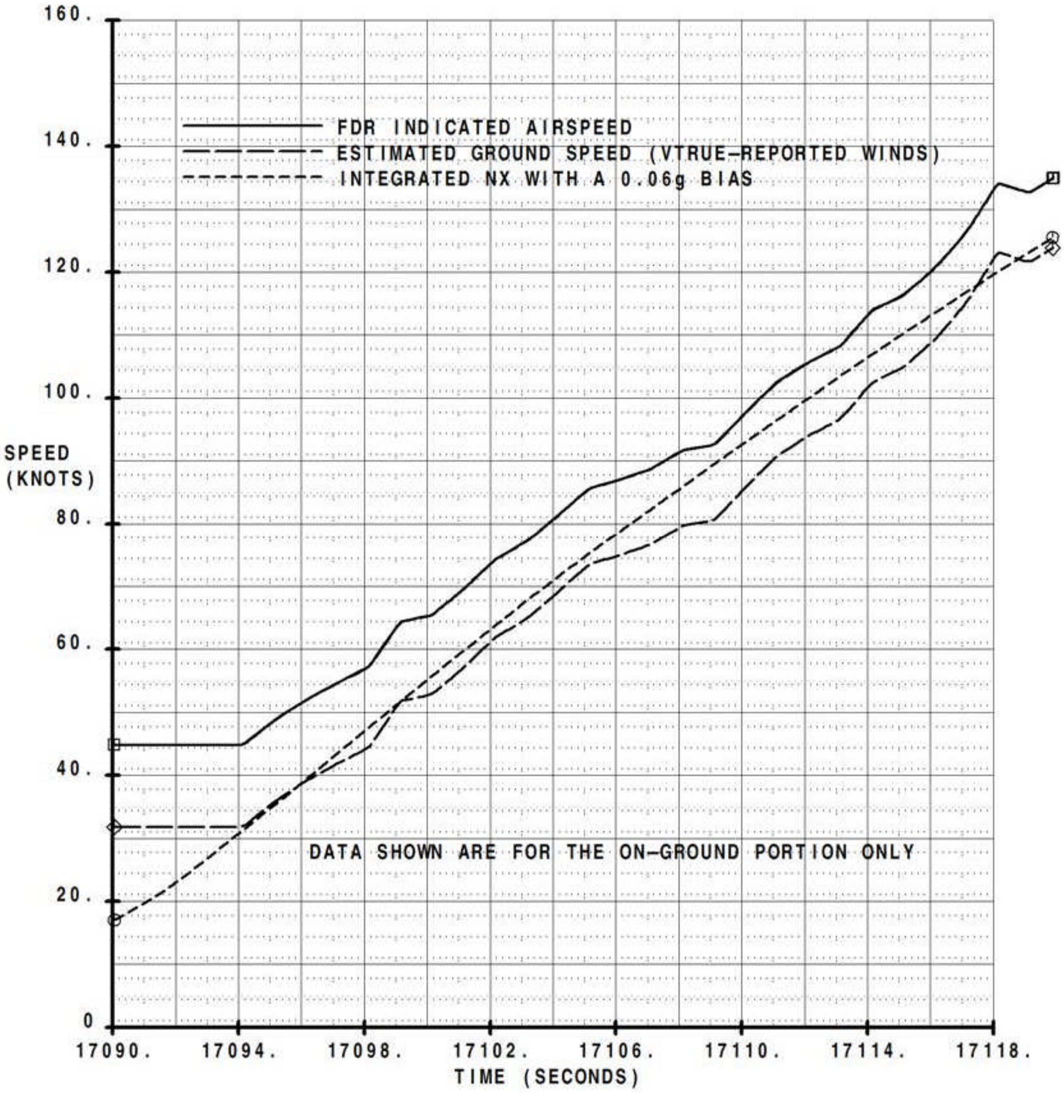
Figure B-1



REV

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APR					B-2
APR					PAGE
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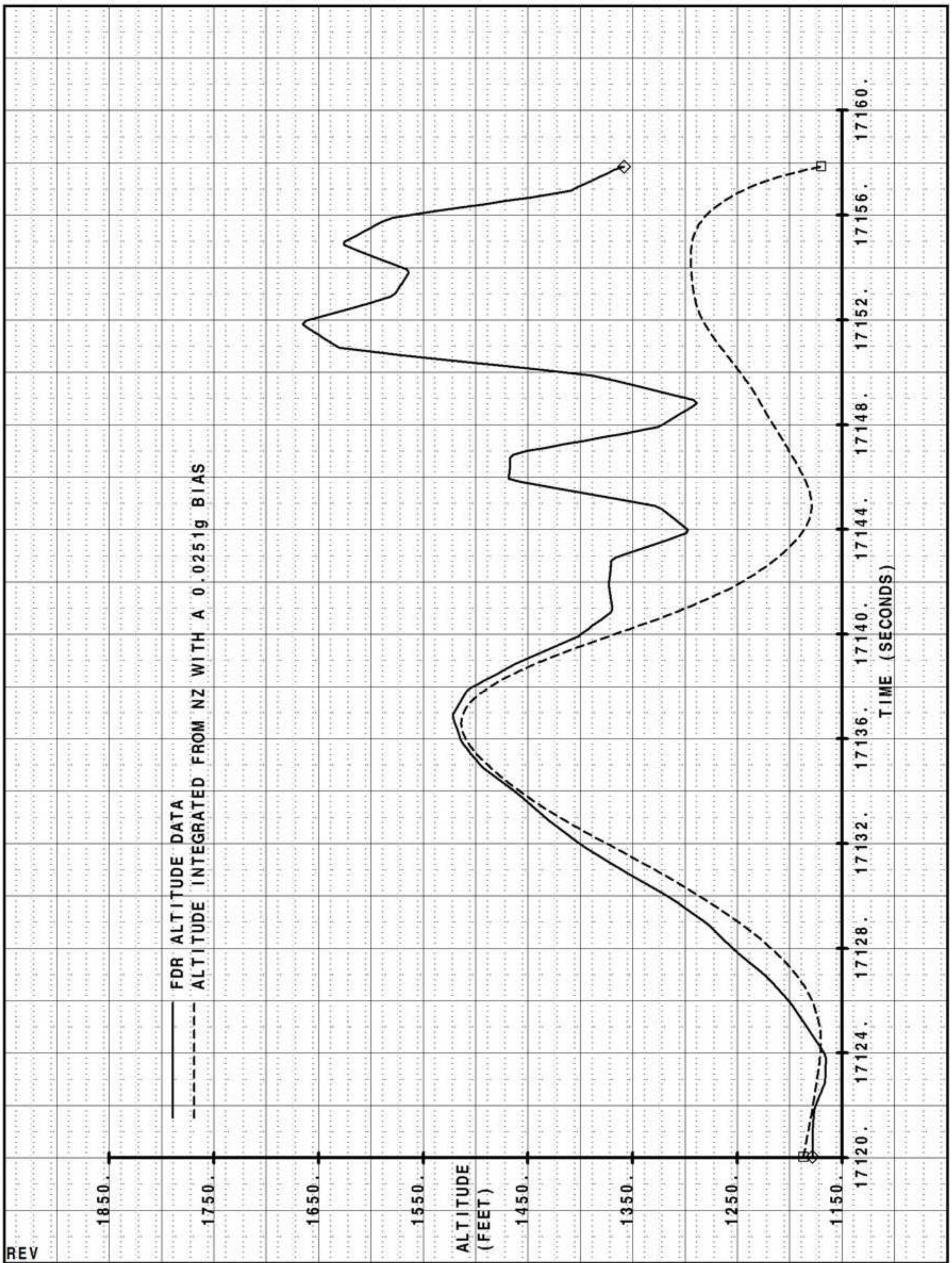

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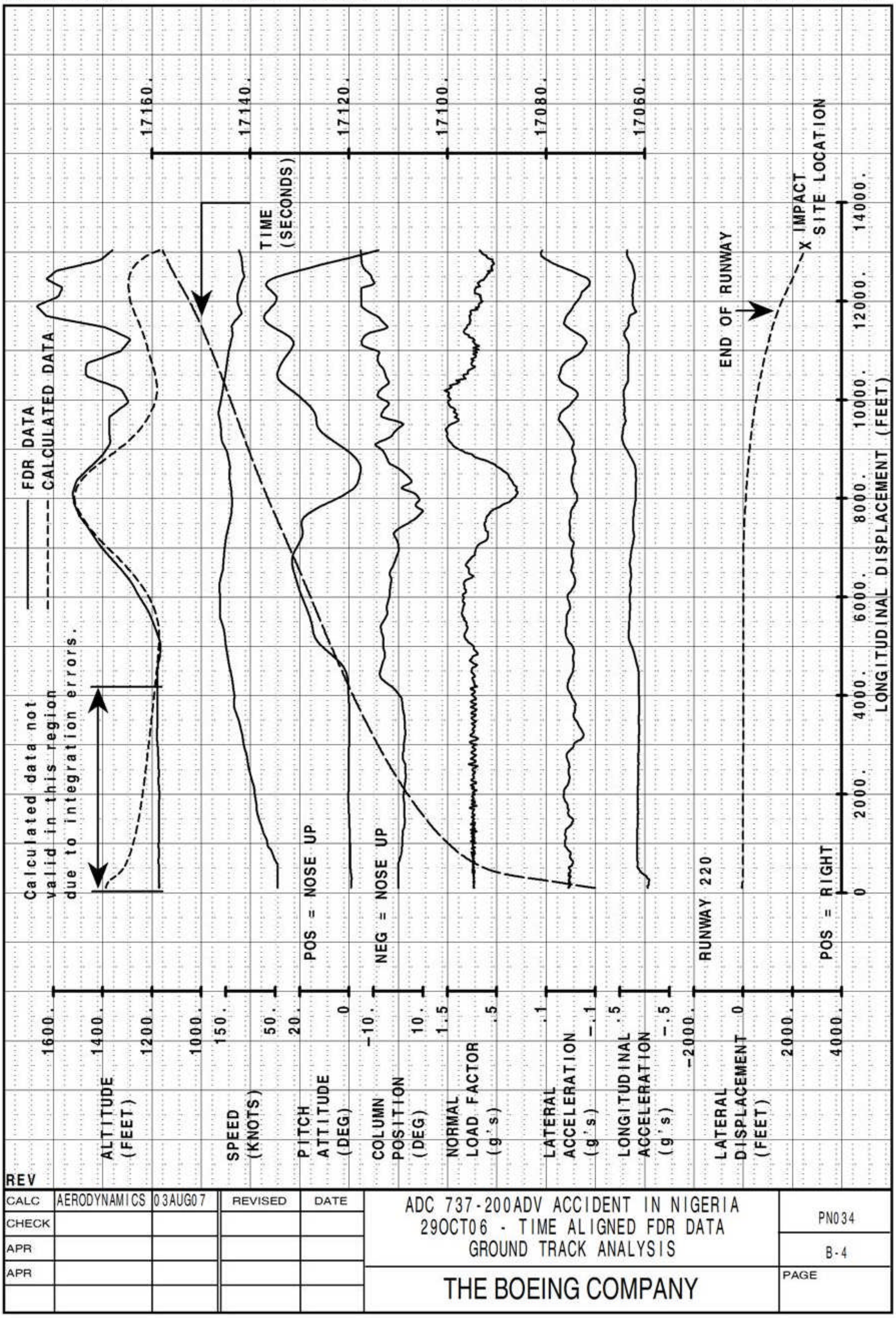
APR					B-3
APR					PAGE
					THE BOEING COMPANY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RUNWAY 220
POS = NOSE UP
NEG = NOSE UP
POS = RIGHT
0 2000. 4000. 6000. 8000. 10000. 12000. 14000.
LONGITUDINAL DISPLACEMENT (FEET)
ALTITUDE (FEET)
1600. 1400. 1200. 1000.
SPEED (KNOTS)
150. 50.
PITCH ATTITUDE (DEG)
20. 0
COLUMN POSITION (DEG)
-10. 10.
NORMAL LOAD FACTOR (g's)
1.5 .5
LATERAL ACCELERATION (g's)
.1 -.1
LONGITUDINAL ACCELERATION (g's)
.5 -.5
LATERAL DISPLACEMENT (FEET)
-2000. 0 2000. 4000.
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GROUND TRACK ANALYSIS
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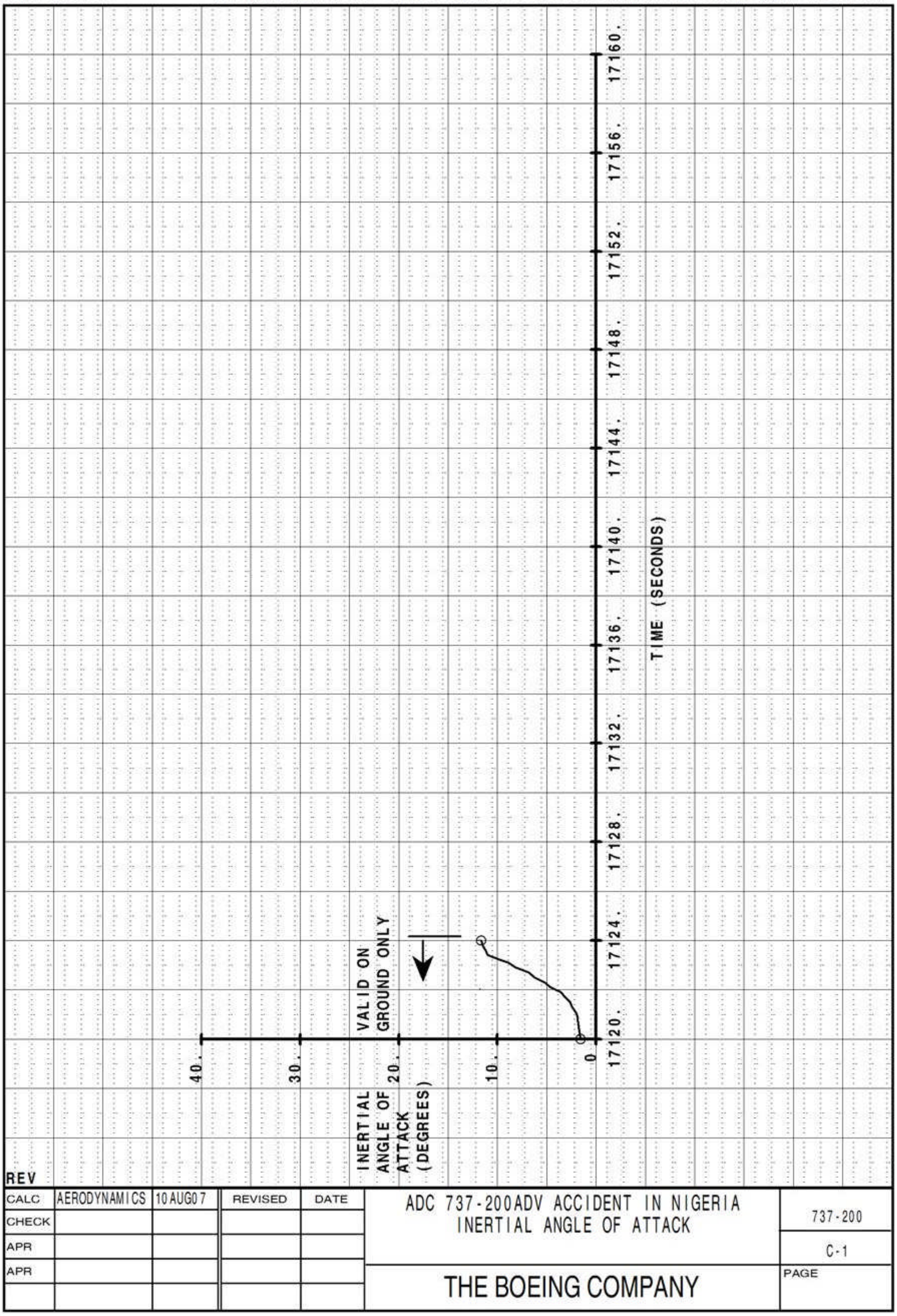
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17124.
17128.
17132.
17136.
17140.
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17152.
17156.
17160.
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10.
20.
30.
40.
INERTIAL ANGLE OF ATTACK (DEGREES)
VALID ON GROUND ONLY
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10AUG07
REVISED
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ADC 737-200ADV ACCIDENT IN NIGERIA
INERTIAL ANGLE OF ATTACK
THE BOEING COMPANY
737-200
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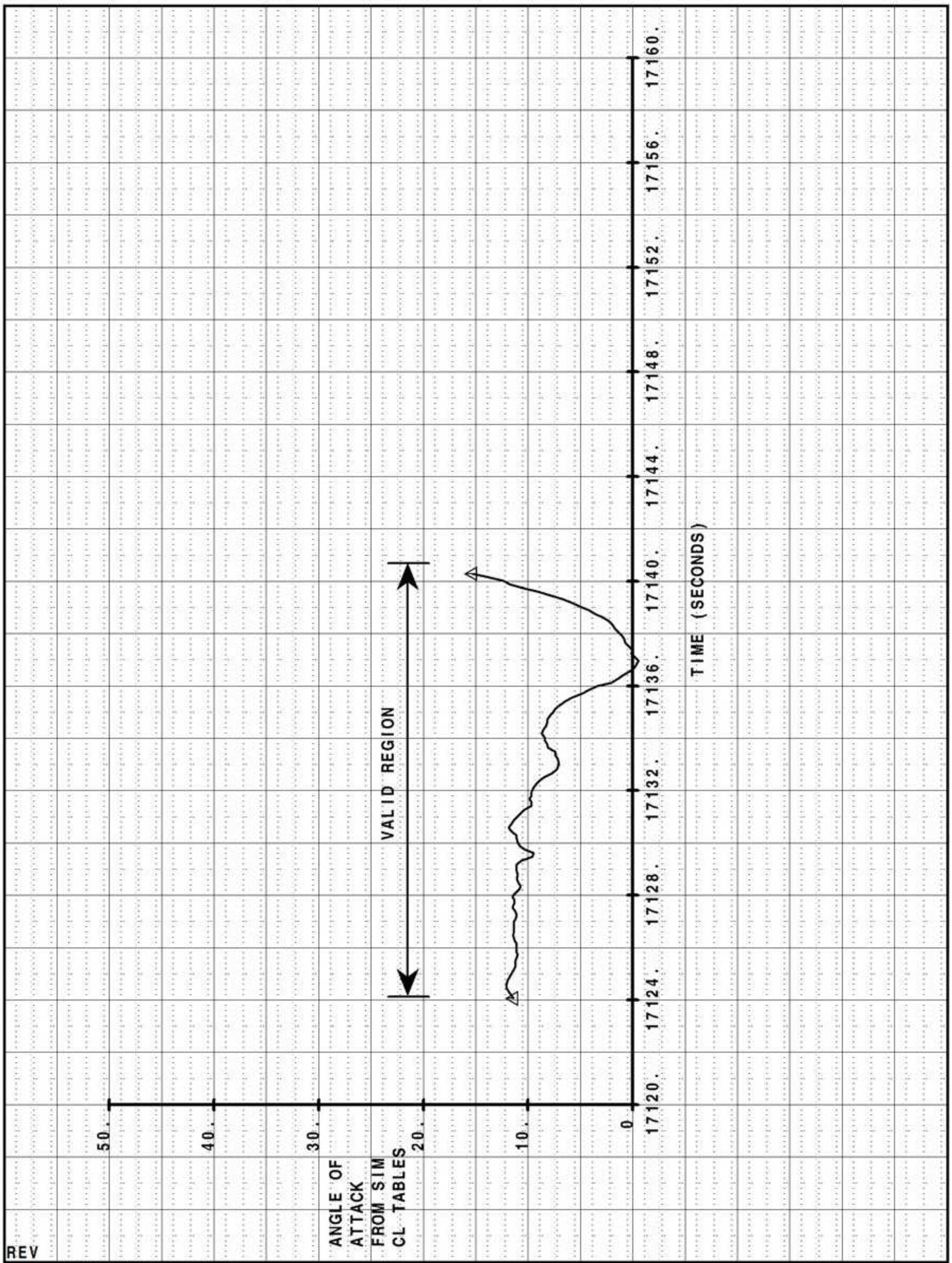

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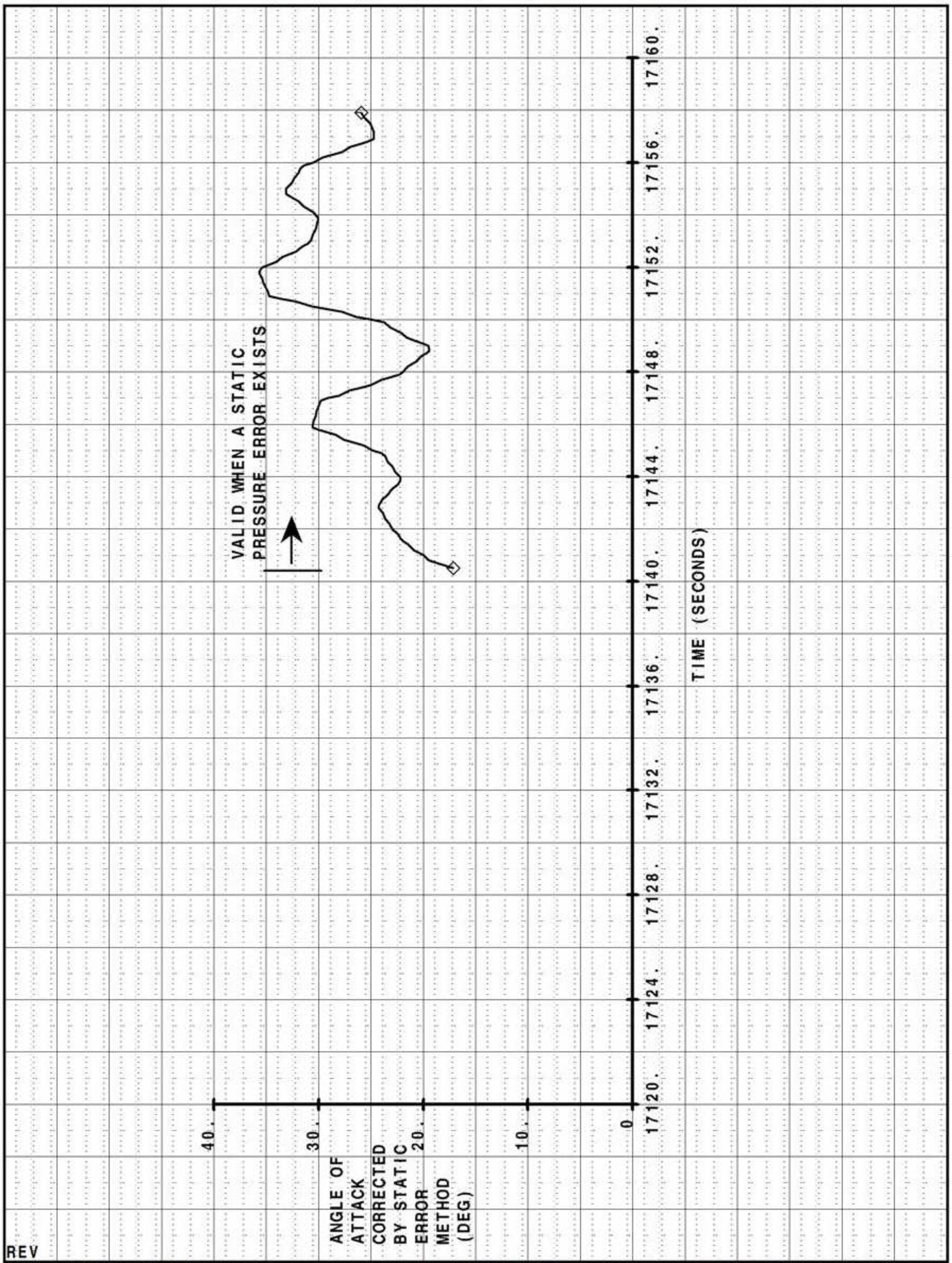

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APR					THE BOEING COMPANY	PAGE
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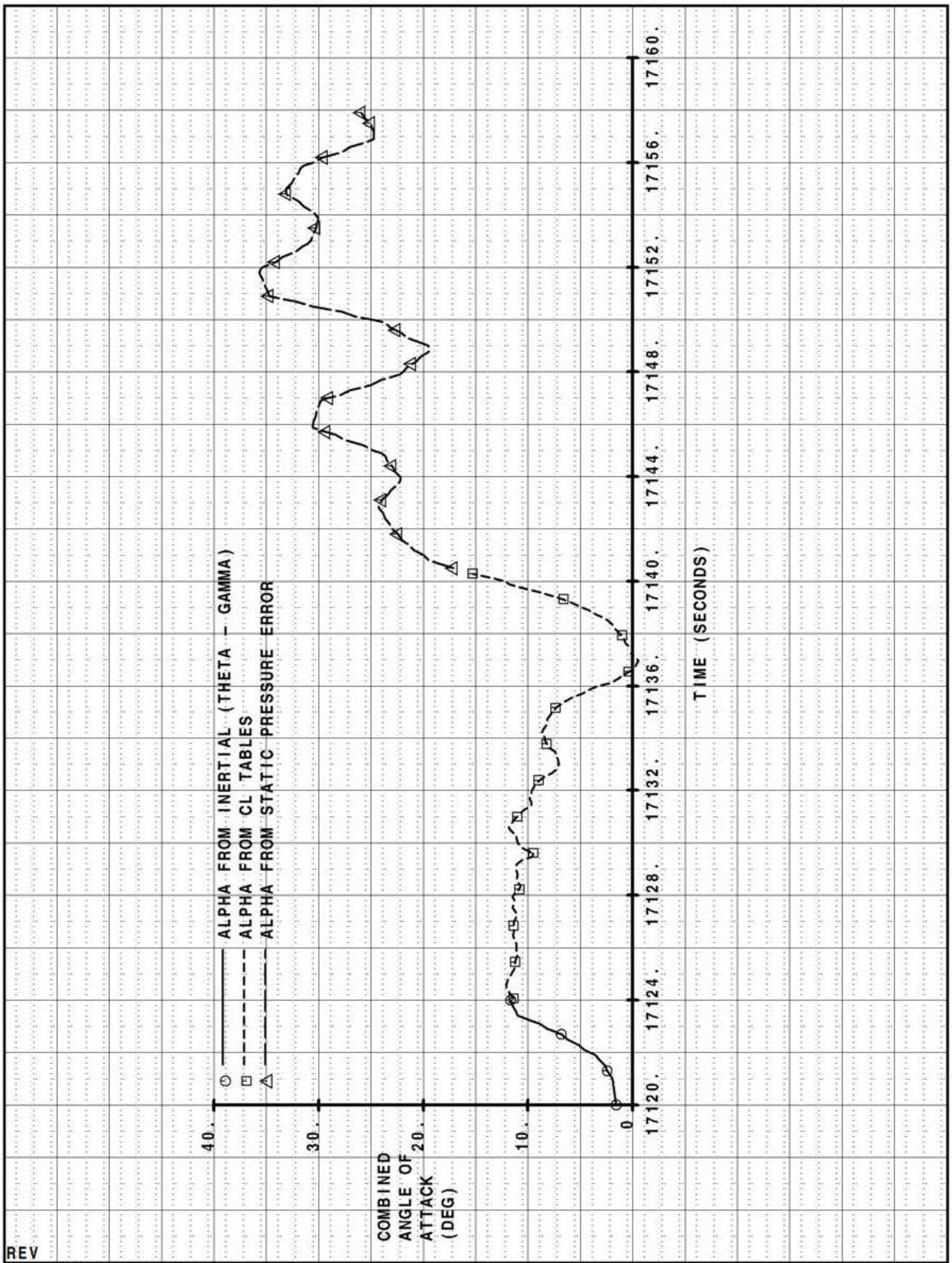

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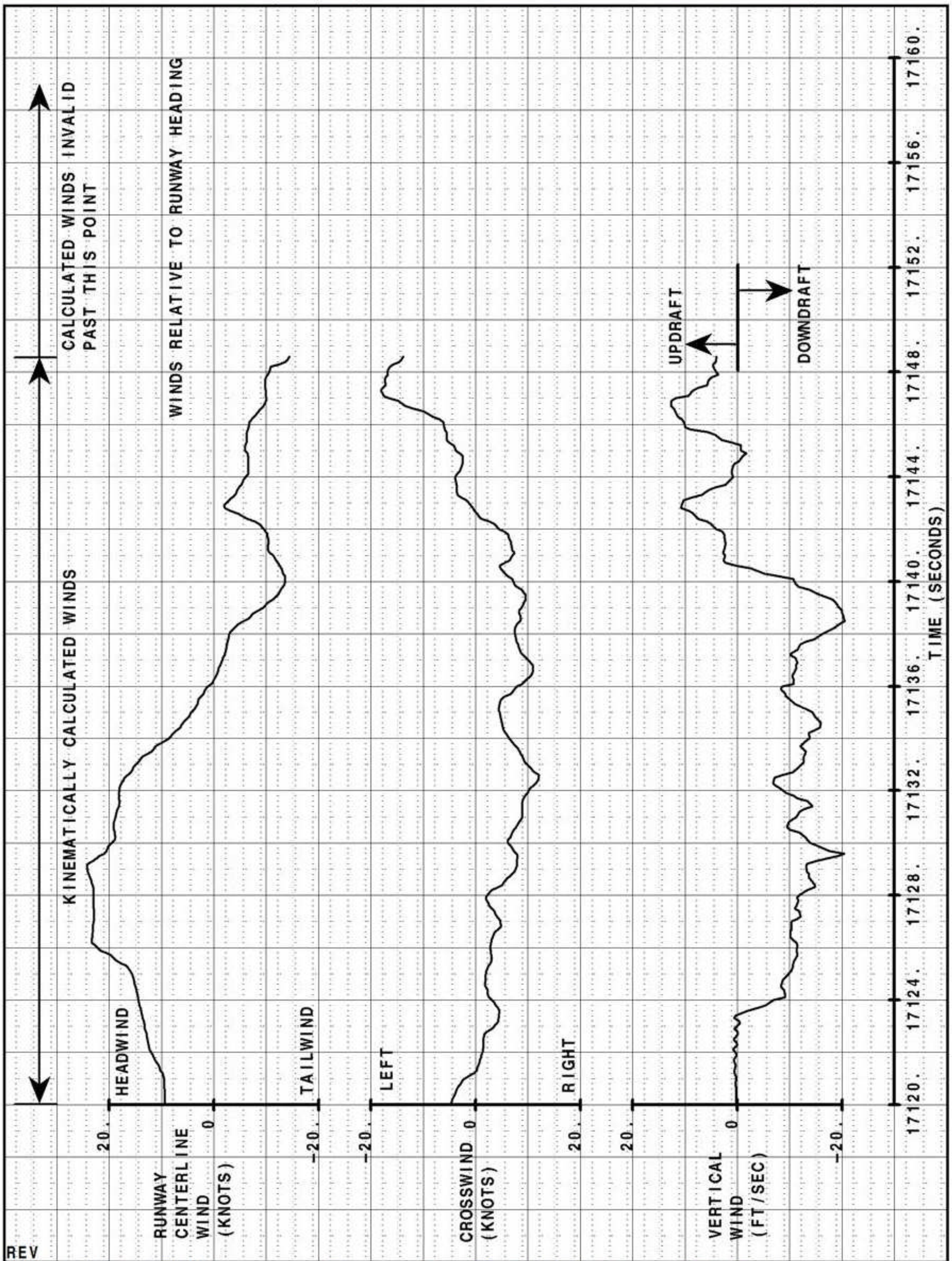

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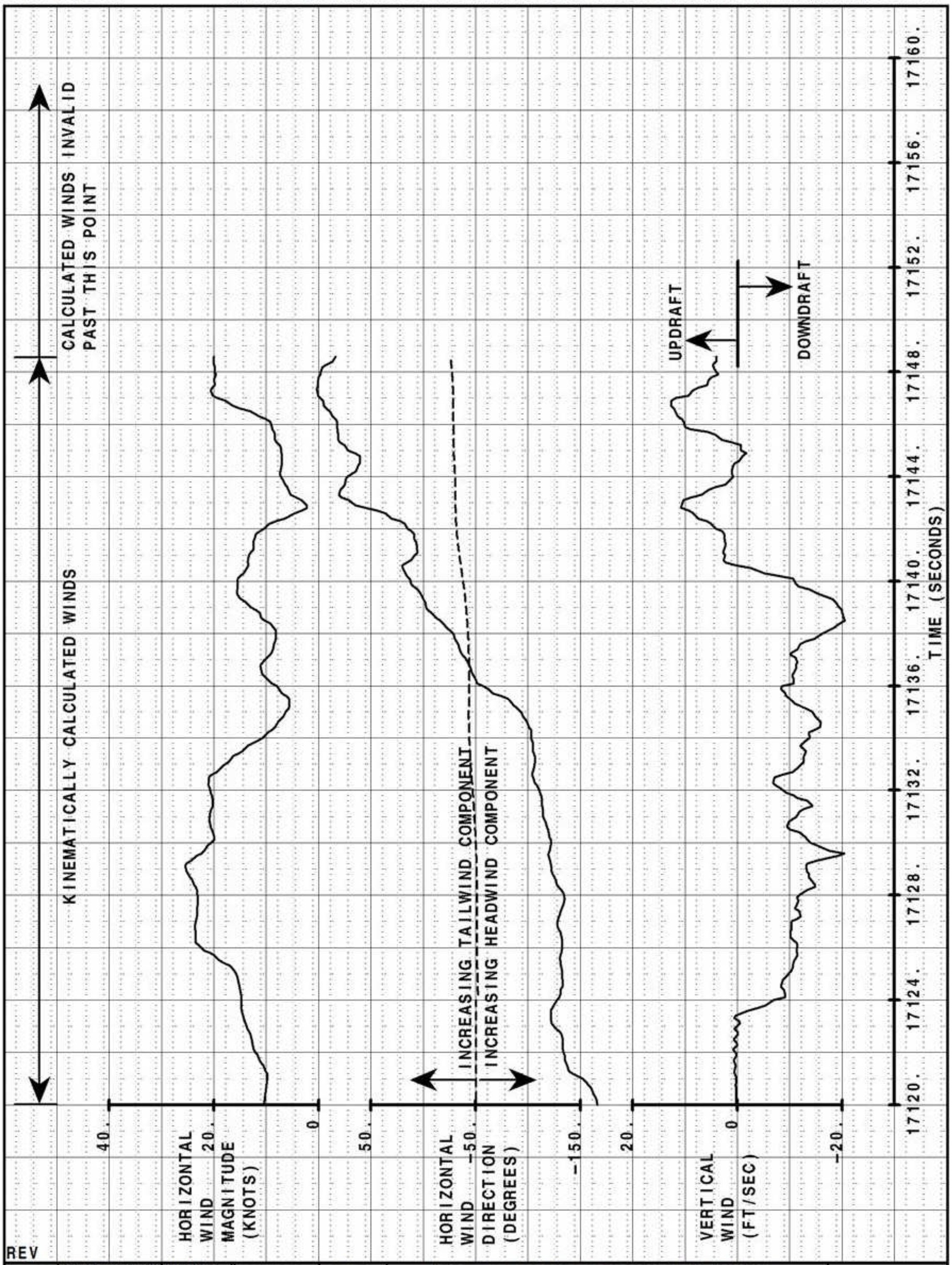

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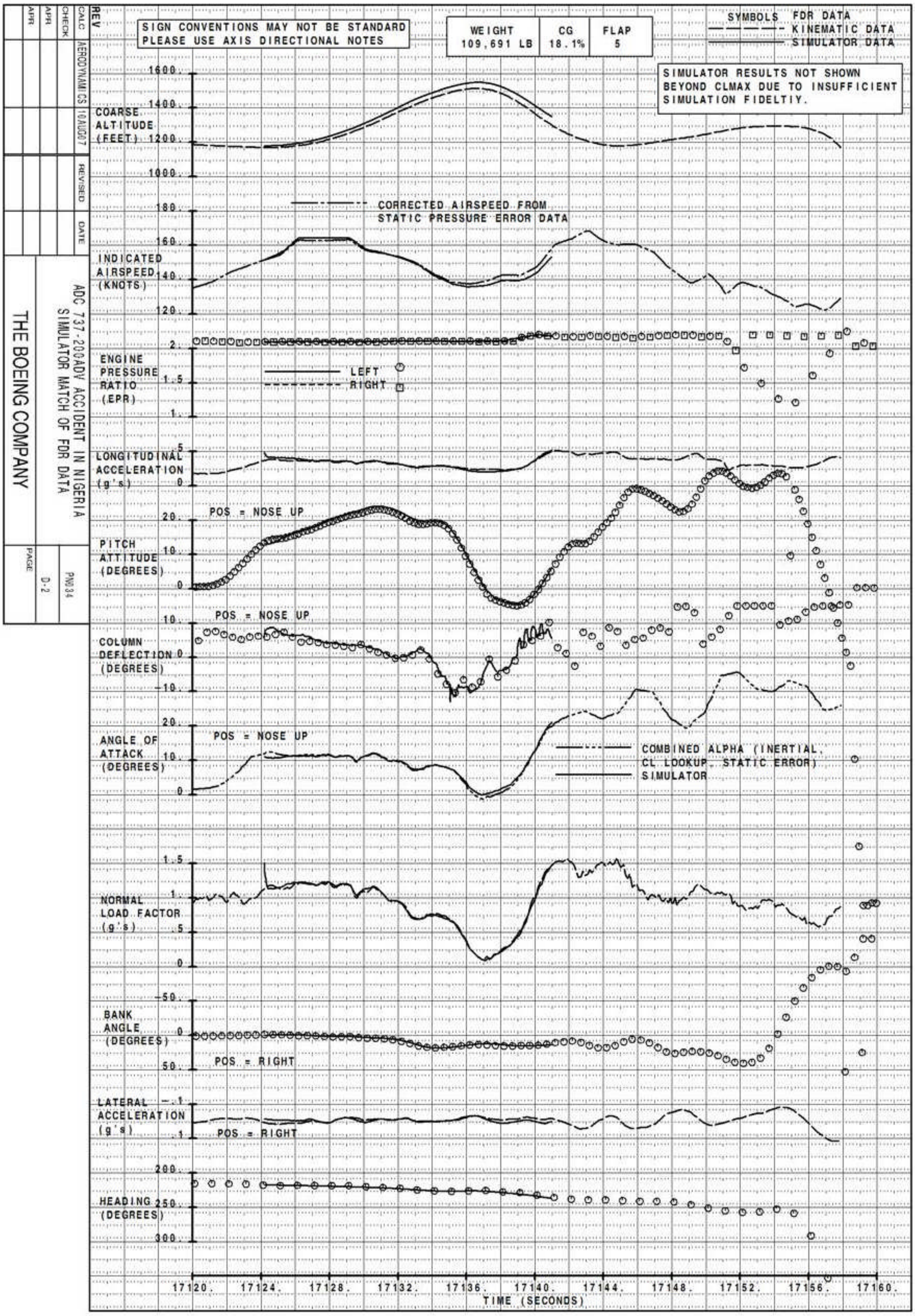
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CG 18.1%
FLAP 5
SYMBOLS FDR DATA
KINEMATIC DATA
SIMULATOR DATA
SIMULATOR RESULTS NOT SHOWN BEYOND CLMAX DUE TO INSUFFICIENT SIMULATION FIDELTIY.
COARSE ALTITUDE (FEET)
CORRECTED AIRSPEED FROM STATIC PRESSURE ERROR DATA
INDICATED AIRSPEED (KNOTS)
ENGINE PRESSURE RATIO (EPR)
LEFT
RIGHT
LONGITUDINAL ACCELERATION (g's)
POS = NOSE UP
PITCH ATTITUDE (DEGREES)
COLUMN DEFLECTION (DEGREES)
ANGLE OF ATTACK (DEGREES)
COMBINED ALPHA (INERTIAL, CL LOOKUP, STATIC ERROR)
SIMULATOR
NORMAL LOAD FACTOR (g's)
BANK ANGLE (DEGREES)
POS = RIGHT
LATERAL ACCELERATION (g's)
HEADING (DEGREES)
TIME (SECONDS)
ADC 737-200ADV ACCIDENT IN NIGERIA
SIMULATOR MATCH OF FDR DATA
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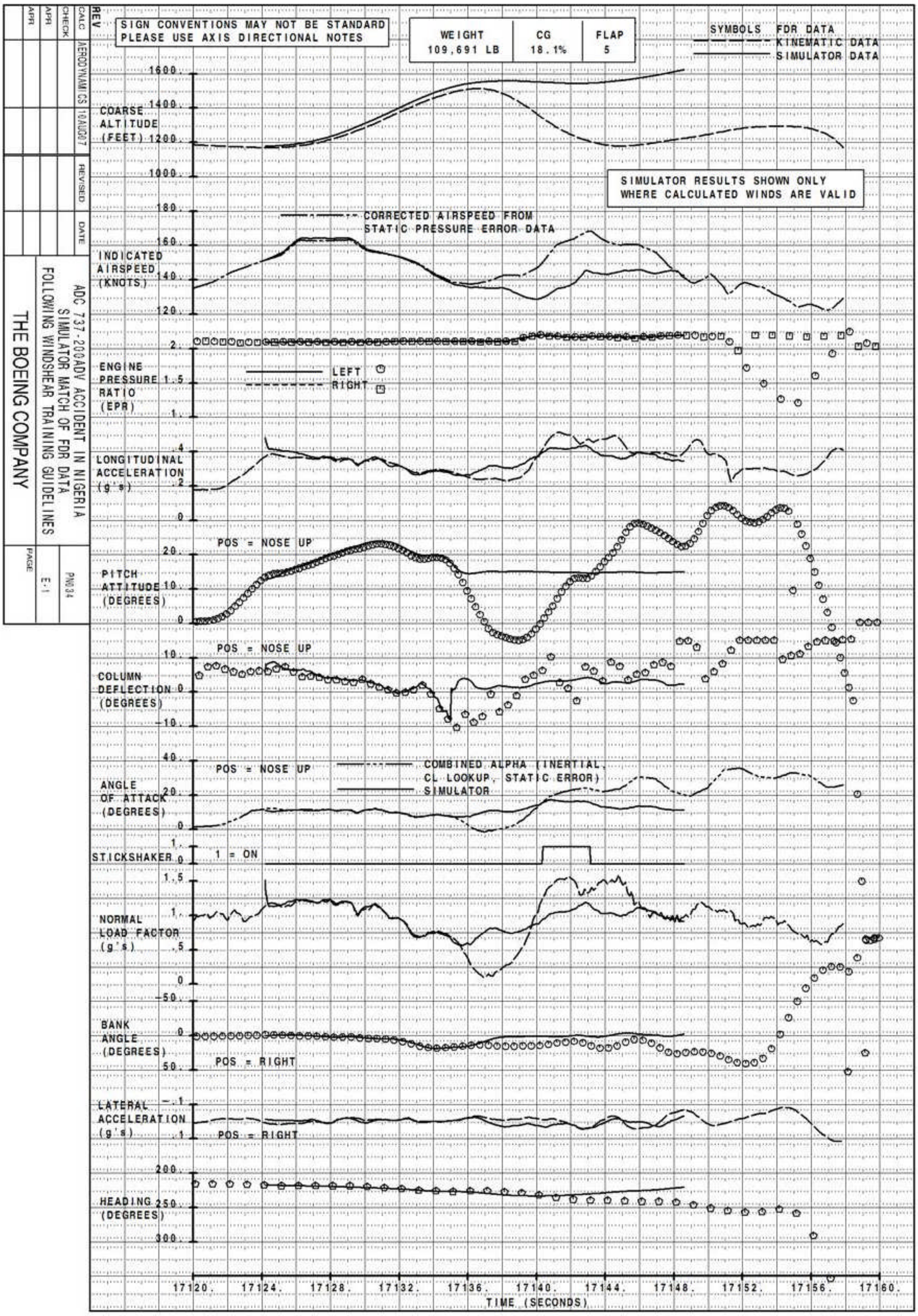

SIGN CONVENTIONS MAY NOT BE STANDARD
PLEASE USE AXIS DIRECTIONAL NOTES
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CG 18.1%
FLAP 5
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KINEMATIC DATA
SIMULATOR DATA
COARSE ALTITUDE (FEET)
SIMULATOR RESULTS SHOWN ONLY WHERE CALCULATED WINDS ARE VALID
CORRECTED AIRSPEED FROM STATIC PRESSURE ERROR DATA
INDICATED AIRSPEED (KNOTS)
ENGINE PRESSURE RATIO (EPR)
LEFT
RIGHT
LONGITUDINAL ACCELERATION (g's)
POS = NOSE UP
PITCH ATTITUDE (DEGREES)
COLUMN DEFLECTION (DEGREES)
ANGLE OF ATTACK (DEGREES)
COMBINED ALPHA (INERTIAL, CL LOOKUP, STATIC ERROR)
SIMULATOR
STICKSHAKER
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BANK ANGLE (DEGREES)
POS = RIGHT
LATERAL ACCELERATION (g's)
HEADING (DEGREES)
TIME (SECONDS)
REV
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10AUG07
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DATE
ADC 737-200ADV ACCIDENT IN NIGERIA
SIMULATOR MATCH OF FDR DATA
FOLLOWING WINDSHEAR TRAINING GUIDELINES
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PN034

GLOSSARY

AARFFS	-	Abuja Aircraft Rescue and Fire Fighting Service
AAIB	-	Air Accident Investigation Branch
Abv	-	Abuja
AIB	-	Accident Investigation Bureau
ADC	-	Aviation Development Company
AGL	-	Above Ground Level
ASL	-	Above Sea Level
ATC	-	Air Traffic Control
ATPL	-	Airline Transport Pilot Licence
CPL	-	Commercial Pilot Licence
CSO	-	Cycle Since Overhaul
CVR	-	Cockpit Voice Recorder
Dir.	-	Direction
DME	-	Distance Measuring Equipment
EEPROM	-	Electrically Erasable Programmable Read Only Memory
EPR	-	Engine Pressure Ratio
FD	-	Flight Director
FDR	-	Flight Data Recorder
Fpm	-	Feet per minute
NCAA	-	Nigerian Civil Aviation Authority
GPWS	-	Ground Proximity Warning System
HF	-	High Frequency
ILS	-	Instrument Landing System
IR	-	Infrared
Lat.	-	Latitude
LLWAS	-	Low Level Windshear Alert System
Long.	-	Longitude
NIMET	-	Nigerian Meteorological Agency
NM	-	Nautical Mile
NTSB	-	National Transportion Safety Board, U.S.A.
Nx	-	Longitudinal acceleration
Ny	-	Lateral acceleration
Nz	-	Vertical acceleration
PAPI	-	Precision Approach Path Indicator
PIC	-	Pilot In Command
PIREPS	-	Pilot Reports
PNF	-	Pilot Not Flying
QNH	-	Barometric Altimeter Setting Which Will Cause Altimeter To Read Altitude Above Mean Sea Level
Sim	-	Simulator

SOPs	-	Standard Operating Procedures
SPECI	-	Special Weather Report
TDWR	-	Terminal Doppler Weather Radar
TOGA	-	Takeoff/go-around
TSO	-	Time Since Overhaul
UTC	-	Universal Time Coordinated
V_1	-	Takeoff Decision Speed
V_r	-	Rotational Speed
V_2	-	Takeoff Safety Speed
VHF	-	Very High Frequency
VOR	-	Very High Frequency Omni-directional Radio Range