DEMOCRATIC PEOPLE'S REPUBLIC OF ALGERIA

MINISTRY OF TRANSPORT

NATIONAL COMMISSION OF INQUIRY

REPORT

on the accident
on 6 March 2003
at Tamanrasset
to the Boeing 737-200
registered 7T-VEZ
operated by Air Algérie

7t-z030306a

F O R E W O R D

This report presents the technical conclusions reached by the national Commission of Inquiry on the circumstances and causes of the accident on 6 March 2003 at Tamanrasset.

The investigation was conducted in accordance with:

- law No 98-06 of 03 Rabie el-Aouel 1419, corresponding to 27 June 1998, which sets the general rules concerning civil aviation, in particular Article 24;
- order No 63-84 of 5 March 1963, relating to the Democratic Republic of Algeria's adherence to the Convention on International Civil Aviation;
- law No 89-165 of 29 August 1989 relating to the administrative powers of the Ministry of Transport;

and to the provisions of Annex 13 of the Convention on International Civil Aviation, with the aim of gathering all information from this accident that may help prevent future accidents.

The sole objective of the investigation into an accident or incident is to draw lessons from this occurrence which may help to prevent future accidents or incidents. It is intended neither to apportion blame, nor to assess individual or collective responsibility (ICAO - Annex 13 - § 3.1).

SPECIAL FOREWORD TO ENGLISH EDITION

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

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GLOSSARY

AD	Airworthiness Directive
ADF	Automatic Direction Finder
ADI	Attitude Director Indicator
AJ	Adjustable Jet
APU	Auxiliary Power Unit
ASDA	Accelerated Stop Distance Available
BEA	French bureau for investigation and analysis for safety in civil aviation
CAS	Computed Air Speed
CG	Center of Gravity
CMB	Climb
CEMPN	Flight crew medical test center
CRM	Crew Resource Management
CRZ	Cruise
CSD	Constant Speed Drive
CSS	Safety and rescue certificate
Cu	Cumulus
CVR	Cockpit Voice Recorder
DACM	Algerian civil aviation and meteorological authorities
EGT	Exhaust Gas Temperature
EPR	Engine Pressure Ratio
FAA	Federal Aviation Administration
FCU	Fuel Control Unit
FDR	Flight Data Recorder
FF	Fuel Flow
FQIP	Fuel Quantity Indicator Panel
ft	Feet
GPWS	Ground Proximity Warning System
HP	High Pressure
HSI	Horizontal Situation Indicator
HSI	Hot Section Inspection
IFR	Instrument Flight Rules
kt	Knot (s)
kW	Kilowatts
LDA	Landing Distance Available
LP	Low Pressure
METAR	Meteorological Aviation Report
MHz	Megahertz
MWS	Master Warning System
N1	Low pressure turbine rotation speed
N2	High pressure turbine rotation speed

NGV	Nozzle Guide Vanes
NM	Nautical mile
NOTAM	Notice to Airmen
NTSB	National Transportation Safety Board
ICAO	International Civil Aviation Organisation
P7	Exhaust pressure
PF	Pilot Flying
PFCU	Power Flight Control Unit
P/N	Part Number
PNF	Pilot Not Flying
PSI	Pounds per Square Inch
QFE	Atmospheric pressure at the aerodrome altitude
QNH	Altimeter setting to obtain aerodrome elevation when on the ground
RMI	Radio Magnetic Indicator
RVSM	Reduced Vertical Separation Minimum
SAT	Static Air Temperature
SC	Stratocumulus
SIGMET	Significant Meteorological Message
RFFS	Rescue and Fire Fighting Service
TAI	Technical Airworthiness Instructions
TCA	Turbine Cooling Air
TCU	Throttle Control Unit
TCAS	Traffic Collision Avoidance System
TODA	Take Off Runway Distance Available
TORA	Take Off Runway Available
TOW	Take Off Weight
VMCA	Minimum Air Control speed
VMCG	Minimum Ground Control speed
VOR	VHF Omnidirectional Range
VR	Rotation speed
VZ	Vertical speed
VZRC	Zero climb speed
ZFW	Zero Fuel Weight

SYNOPSIS

Date and time
Thursday 6 March 2003
at 14 h 15 min(1)

Site of accident
Tamanrasset Aguenar Aerodrome

Type of flight
Public transport of passengers
Scheduled domestic flight DAH 6289
Tamanrasset – Ghardaïa - Algiers

Aircraft
Boeing 737-200
registered 7T-VEZ

Owner
Air Algérie

Operator
Air Algérie

Persons on board
2 Flight crew
4 Cabin crew
97 Passengers

Summary

During takeoff from runway 02 at Tamanrasset Aguenar aerodrome, a sharp thump was heard just after rotation. The left engine had just suffered a contained burst. The airplane swung to the left. The Captain took over the controls. The airplane lost speed progressively, stalled and crashed, with the landing gear still extended, about one thousand six hundred and forty-five meters from the takeoff point, to the left of the runway extended centerline.

Consequences

				Equipment
	Killed	Injured	Uninjured	
Crew	6	-	-	Destroyed
Passengers	96	1	-	
Third parties	-	-	-	

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

ORGANISATION OF THE INVESTIGATION

On Thursday 6 March 2003, the Ministry of Transport was informed of an accident at the Tamanrasset Aguenar aerodrome to a Boeing 737-200 registered 7T-VEZ belonging to Air Algérie, the national airline.

In accordance with the Provisions of Annex 13 of the Convention on International Civil Aviation and the existing legislation, a Commission of Inquiry was established by decision No 283/cab/M of the Minister of Transport on 6 March 2003 (see appendix 1).

This Commission, led by the Inspector General of the Ministry of Transport, went to Tamanrasset on the day of the accident, arriving there at 21 h 15 min.

The Commission immediately started work and undertook:

- a visit to the accident site and an initial examination of the wreckage, ensuring that appropriate steps were taken to preserve and protect the evidence;
- interviews with those persons directly involved in the preparation of the flight;
- interviews with eyewitnesses;
- listening to the recordings of the air/ground communications.

The Commission determined a work program and adopted the most appropriate working methods to achieve the planned objectives in the shortest possible time. The Commission decided to request technical support from the BEA, the French bureau for investigations and analysis for safety in civil aviation.

The United States were associated with the investigation as State of Manufacture of the airplane. The NTSB named an Accredited Representative, who was assisted by experts from the FAA, Boeing and Pratt & Whitney.

The work of the investigation consisted of:

- establishing a plan of the marks on the ground, the position of the parts of the wreckage and the indications on the cockpit instruments, photographs being taken as a record;
- readout of the airplane's flight recorders in the BEA's laboratories, then analysis of the recordings, using performance calculations provided by the manufacturers of the airplane and the engine;
- additional examinations of the wreckage;
- examination of both of the accident airplane's engines in SNECMA's Brussels workshops, followed by further examination of engine parts at the official CEPr engine test center in France;

- examination of equipment from the airplane at Boeings' workshops in Seattle (USA);

- examination of survival aspects for the crew and passengers;

- flight simulator research;

- examination of the training of Air Algérie crews and of the flight safety organization.

During the investigation, the commission met regularly to organize the work in progress. Seven meetings, each lasting several days, open to investigators from foreign countries, were held to analyze the results of the work and to review progress.

The commission met the victims' families on two occasions to keep them informed of the progress of the investigation.

The entire operation was carried out in accordance with national and international procedures, in coordination with the relevant local authorities.

In accordance with Annex 13 provisions, the draft report was addressed for consultation to the BEA and the NTSB. These two organizations indicated that they agreed with the report and had no additional comments.

1 - FACTUAL INFORMATION

1.1 History of the Flight

On Thursday 6 March 2003, the Boeing 737 registered 7T-VEZ, operated by Air Algérie, was taking off from Tamanrasset to undertake, with a three-hour delay, scheduled flight DAH 6289 to Ghardaïa and Algiers. Six crew members (two flight crew and four cabin crew) and 97 passengers were on board. The co-pilot was pilot flying.

No technical exemptions or deferred maintenance items applied to the airplane; on departure from Algiers it had been subject to routine maintenance for a minor technical problem, a hydraulic pump having been changed in the circuit B landing gear bay.

The speeds decided on by the crew were V1 = 144 kt, VR = 146 kt, V2 = 150 kt. The EPR displayed was 2.18, that is to say nominal maximum thrust on take-off.

At 14 h 01 min 37 s, the crew requested start-up clearance.

At 14 h 08 min 36 s, the tower cleared the airplane to taxi, enter and taxi up runway 02. The wind was 330 at 12 kt.

At 14 h 12 min 30 s, the co-pilot called out “we’re ready”.

At 14 h 12 min 31 s, the tower cleared flight 6289 to line up and take off.

At 14 h 13 min 36 s, flight DAH 6289 announced take-off.

About five seconds after airplane rotation, at the moment when gear retraction was requested, a sharp thumping noise was recorded on the CVR. The airplane’s heading veered to the left, followed by a track correction.

The Captain announced that he was taking over the controls. A short time later, the co-pilot told the control tower “we have a small problem”.

The airplane continued to climb and reached a recorded height of about 400 ft.

The speed dropped progressively from 160 kt during airplane lift-off to stall speed at the end of the recording. In fact, about ten seconds before, the noise of the stick shaker is heard on the CVR (which usually indicates that the airplane is 7% from its stall speed).

The “Don’t Sink” aural warning, which normally indicates a loss of altitude during take-off when the airplane is below nine hundred feet, appeared about six seconds before the end of the recording.

The airplane, with landing gear extended, struck the ground on its right side. A severe fire broke out immediately. The airplane slid along, losing various parts, struck and knocked over the airport perimeter fence then crossed a road before coming to a halt in flames.

The control tower immediately sounded the alert.

1.2 Injuries to persons

Injuries	Crew members	Passengers	Others
Fatal	6	96	-
Serious	-	1	-
Light/none	-	-	-

1.3 Damage to Aircraft

The airplane was destroyed by the impact and the fire.

1.4 Other Damage

About two hundred and fifty meters of the aerodrome perimeter fence was damaged.

1.5 Personnel Information

1.5.1 Flight Crew

The crew had no known condition preventing them from carrying out their duties.

1.5.1.1 Captain

Male aged 48

- Aeronautical qualifications:
    - Professional Pilot's License No 285 issued on 9 December 1979;
    - Public transport pilot's license No 285 issued on 19 September 1992;
    - IFR rating obtained on 9 December 1979;

- Beech BE 70 obtained on 17 November 1980;
- B 727 obtained on 30 November 1982;
- L 382G obtained on 31 October 1985;
- F 27 obtained on 31 March 1992;
- B 767 obtained on 2 March 1994;
- B 737 obtained on 20 June 2001;
- CRM training course on 9 February 2002;
- RVSM training course on 5 December 2001;
- Simulator check on B 737 on 13 January 2003;
- Line check B 737 on 6 February 2003;
- Last medical check at the CEMPN (Algiers) on 1st October 2002.

- Professional experience:

  - 10,760 h 10 min total flying hours, of which 1,087 h 46 min on type as Captain;
  - over the previous six months: 206 h 15 min flying hours on type;
  - over the previous three months: 85 h 35 min flying hours on type;
  - over the previous thirty days: 40 h 35 min flying hours on type.

The Captain also flew on Boeing 767's as co-pilot. In this role, he had also flown 31 h 57 min over the previous thirty days.

1.5.1.2 Co-pilot

Female aged 44

- Aeronautical qualifications:

  - Professional pilot's license No 702 issued on 29 October 1997;
  - IFR rating obtained on 10 December 1997;
  - CESSNA C 208B rating obtained on 29 October 1997;
  - Beech BE 100 rating obtained on 25 November 1997;
  - Beech BE 1900 rating obtained on 12 June 2000;
  - B 737 rating obtained on 13 January 2001;
  - CRM training course on 20 March 2002;
  - RVSM training course on 18 December 2001;
  - Cessna line check on 11 January 1998;
  - BE 100 line check on 15 June 1998;
  - BE 1900 line check on 26 September 2001;
  - B 737 line check on 6 January 2003;
  - BE 1900 base check on 21 April 2000;
  - B 737 base check on 4 November 2002;
  - Last medical check at the CEMPN (Algiers) on 12 October 2002.

- Professional experience:

  - 5,219 h 10 min flying hours of which 1,292 h 42 min on type;
  - over the previous six months: 411 h 54 min flying hours on type;

- over the previous three months: 201 h 42 min flying hours on type;
- over the previous thirty days: 62 h 42 min flying hours on type.

1.5.2 Cabin crew

1.5.2.1 Chief Flight Attendant

Male aged 48

- Initial CSS training certificate No 590 issued 28 April 1979.
- B 737-200 qualification: 19 March 2001.
- Appointment as Chief Flight Attendant: 16 June 2001.

1.5.2.2 Flight Attendants

Female aged 32

- Initial CSS training certificate No 1738 issued on 5 December 2000.
- B 737-200 qualification on 24 April 2000.

Female aged 24

- Initial CSS training certificate No 1475 issued on 25 July 1999.
- B 737-200 qualification on 24 March 2001.

Female aged 26

- Initial CSS training certificate No 1845 issued on 17 February 2001.
- B 737-200 qualification on 17 June 2000.

1.6 Aircraft Information

1.6.1 Airframe

1.6.1.1 General

- Manufacturer: The Boeing Aircraft Company (USA)
- Type: Boeing 737 - 200 version 2T4
- Serial number: 22700
- Airworthiness Certificate 14326 issued 20 December 1983, valid until 7 June 2003
- Date of entry into service with Air Algérie: 9 December 1983
- 5 March 2003: 41,472 hours and 27,184 cycles

1.6.1.2 Maintenance

The airplane was maintained by Air Algérie in accordance with the approved maintenance manual. It was up to date in its maintenance cycle, including in the application of TAI's. No work was deferred during the last maintenance operation.

After repairs carried out due to a minor technical problem (change of a circuit B hydraulic pump) the airplane had no technical exemptions and was in accordance with regulatory performance requirements.

The last maintenance checks had been performed on the dates listed below.

Most recent checks				
Type	Hours	Cycles	Start	Finish
D	37,922	24,538	5 November 2000	30 November 2001
C	40,987	26,829	7 October 2002	24 November 2002
V2 (A check)	41,400	-	18 February 2003	20 February 2003

Flying hours since checks		
Type	Hours	Cycles
D	3,550	2,646
C	485	355
V2 (A check)	72	-

1.6.2 Engines

- Manufacturer: Pratt & Whitney (USA)
- Type: JT8 D - 17A

	Position 1 (left)	Position 2 (right)
Serial number	709385	709369
Installation date	4 November 2002	21 May 2001
Total hours	30,586	22,884
Total cycles	20,040	15,316
Last overhaul	10 February 1999	6 January 1994
Hours/cycles since last overhaul	6,729 / 4,285	10,652 / 7,879
Last HSI	25 July 2002	26 January 2000
Hours/cycles since last HSI	485 / 355	4,649 / 3,353

The JT8 D engine is a ducted low bypass ratio fan engine. It has lower inertia when it is stopped than more powerful new generation engines with a higher bypass ratio.

Note: following repeated notification of problems with re-conditioned parts from the high-pressure section on the engine (NGV 1), parts received are systematically subjected to inspection (aerofoil and dimensions) by Air Algérie. Parts that are out of specification represent between 5% and 10% of the parts received.

1.6.3 Fuel

Before the flight, an additional 5,840 liters of JET A, or 4.6 tons, was added. In total, adding the fuel that was on board on arrival, 5.4 tons, the quantity of fuel on board was about 10 tons.

Note: this operation was carried out in manual mode by two mechanics, one on the ground and the other in the cockpit, because of the unreliability of the center tank fuel gauge located on the refueling panel.

1.6.4 Weight and Balance

1.6.4.1 Weight

The weight of fuel taken into account by the ramp operations technician (TNA/O) to establish the load status was incorrect (8,800 instead of 9,800 kg). In addition, two absent passengers had been included in the count. These errors were identified and corrected by the co-pilot. Taking this into account, the airplane's take-off weight (TOW) was 48,708 kg, compared to a maximum authorized weight of 49,500 kg.

1.6.4.2 Balance

On the basis of the fuel on board and taking into account the loading carried out, the balance on takeoff was 22.70%. This value is within the normal range for airplane usage.

1.7 Meteorological Information

Observations at the aerodrome on 6 March, 2003:

13 h 00
Calm wind visibility 40 km Clouds 6/8 at 7,000m, no phenomena
T = 23/-10 QNH 1020 Hpa QFE 865 Hpa

13 h 30
Calm wind visibility 40 km Clouds 6/8 at 7,000m, no phenomena
T = 23/-10 QNH 1020 Hpa QFE 865 Hpa

14 h 00
Calm wind visibility 40 km Clouds 6/8 at 7,000m, no phenomena
T = 23/-5 QNH 1019 Hpa QFE 865 HPa

1.8 Aids to Navigation

Not applicable.

1.9 Communications

The transcript of radio communications recorded between 7T-VEZ and Tamanrasset control tower on the 118.1 MHz frequency is included in appendix 2.

1.10 Aerodrome Information

Tamanrasset Aguenar, map reference 022° 48' 40" N/005° 27' 03" E, is a controlled civil aerodrome open to public air traffic. It has two runways:

- 02/20 3,600 meters long 45 meters wide
- 08/26 3,100 meters long 45 meters wide

Its reference altitude is 1,377 meters.

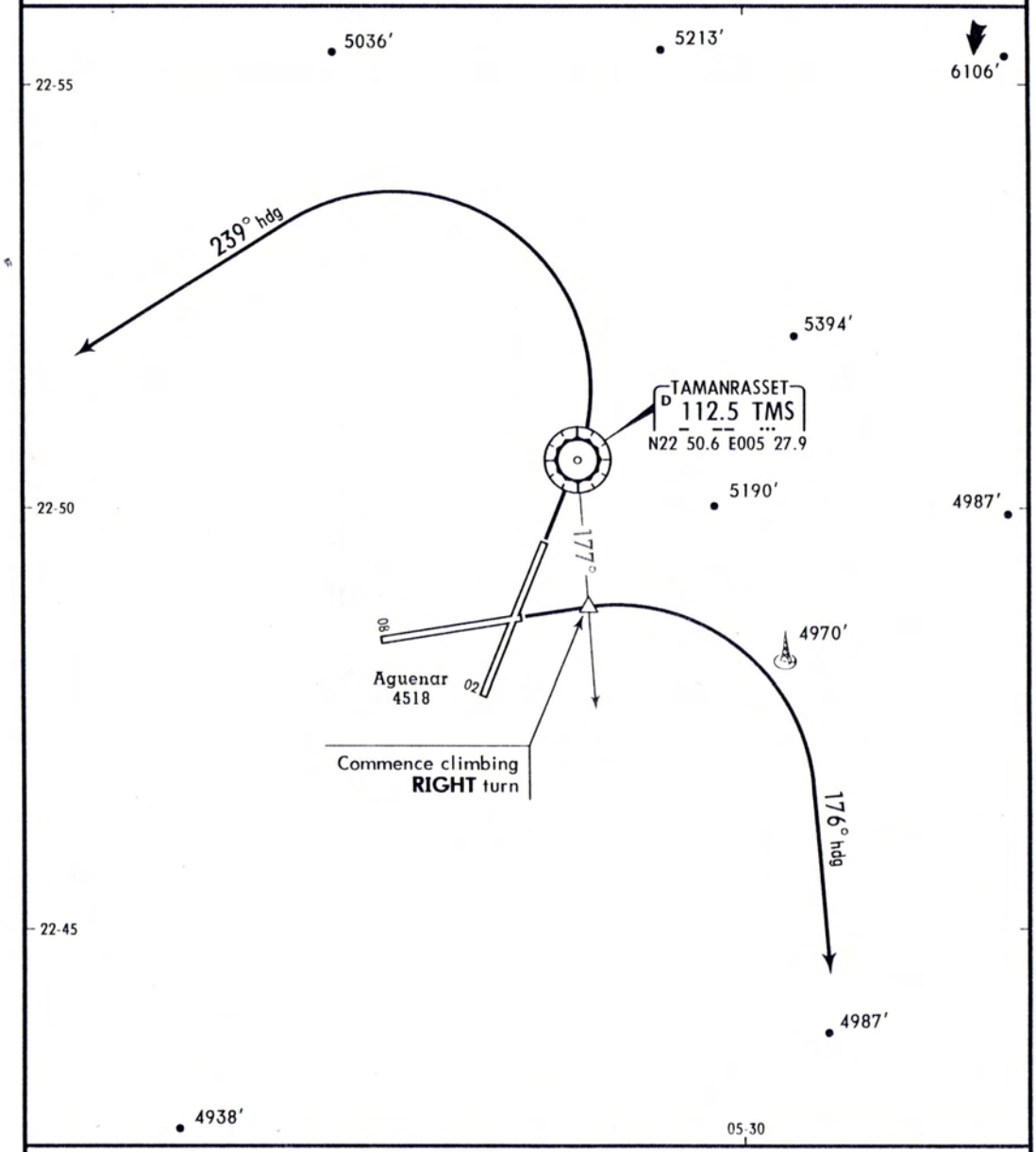
The rescue and fire fighting services protection level is 7 (ICAO classification), which corresponds to two vehicles manned by four firemen managed by an operations chief.

At the time of the accident, the fire service was equipped with three vehicles.

The one engine out procedure to be applied is described below:

TAMANRASSET, ALGERIA
AGUENAR

ONE ENGINE OUT PROCEDURE
(RWYS 02, 08)



ONE ENGINE OUT PROCEDURE
(RWY 02)

At TMS VOR climbing turn LEFT to hdg 239°.

ONE ENGINE OUT PROCEDURE
(RWY 08)

Upon crossing R-177 TMS climbing turn RIGHT to hdg 176°.

CHANGES: Aircraft type added.

1.11 Flight Recorders

1.11.1 Types and readout operations

In accordance with the statutory requirements, the airplane was equipped with two recorders:

- a Fairchild model A100 cockpit voice recorder (CVR), serial number 4492;
- a Honeywell model 980-4120-GQUN flight data recorder (FDR), whose serial and model numbers were not legible on the recorder.

Readout of these recorders was performed on 13 March 2003 at the BEA.

1.11.2 CVR readout

The CVR had suffered little damage, though its condition required its protective case being cut open before tape extraction.

The Fairchild A100 CVR magnetic tape has four tracks that correspond to the four channels recorded in a thirty minute loop. A readout of the tape was made on an adapted REVOX player after adjusting the tape travel speed using the 400 Hz on-board electrical power supply signal.

The languages used by the crew on the recording are English, French and Arabic. The transcript of the recording is in Appendix 3.

1.11.3 FDR readout

The flight data recorder had no visible deformations, but showed signs of heavy exposure to fire. The outer casing was removed without difficulty.

The data acquisition card situated under the protective case was charred. Inside the protective case the memory card was in place and in perfect condition. This memory card was connected to the chassis of a recorder of the same type whose recording function was inhibited. The combination thus formed allowed direct readout of the data.

Note: the technician did not have a precise and updated conversion document allowing the transformation of the recorded data in binary form to physical data. Additional work was therefore necessary to be able to read out the data.

Only the following parameters were recorded: time, pressure altitude, speed, magnetic heading, vertical acceleration, and send/receive VHF communications. The graph is included in appendix 4.

1.11.4 Summary

In comparing the two recordings, the following elements are of note:

Flight preparation was carried out by the co-pilot alone. At her request, the Captain authorized her to perform the flight leg.

The chief steward was present in the cockpit from time to time during flight preparation and during the take-off. He was talking with the Captain.

The copilot began the pre-take-off briefing by announcing the speeds for V1 (144 kt), VR (146 kt) and V2 (150 kt); she was interrupted by the Captain.

At 14h 12 min 47, the crew was authorized to line up on runway 02 and to take off. The wind, as given by the tower controller, was 330° at 12 kt.

Note: during communications with ATC, the crew was using hand mikes.

At 14 h 14 min 47, that is fifty-two seconds after engine power-up, the Captain announced rotation, at about 150 kt. The magnetic heading was 020°.

At 14 h 14 min 51, the speed of the plane reached 160 kt; it subsequently fell until the end of the flight.

At 14 h 14 min 52, the copilot asked for landing gear retraction (Gear Up callout). This request was immediately followed by a sharp thumping noise. The airplane's speed was then 158 kt, its height in relation to the threshold of runway 02 was 78 ft and its magnetic heading was 018°.

The plane veered to the left and at 14 h 14 min 55, its magnetic heading was 008°. A series of exclamations from the co-pilot, followed by "what’s going on" is heard.

Note: from the FDR data, the vertical speed on initial climb was calculated as between 1,400 and 1,800 ft/min.

From 14 h 15, the Captain asked the co-pilot several times to let go of the controls. The co-pilot read back and, three seconds later, spoke to the Captain and offered to retract the landing gear. There was no response.

At 14 h 15 min 04, the co-pilot told the controller "we have a small problem".

At 14 h 15 min 06, the stick shaker is heard for one second. The airplane's height in relation to the runway 02 threshold was then at its maximum (398 ft). Its speed was 134 kt.

At 14 h 15 min 08, the stick shaker is heard for a half second.

At 14 h 15 min 10, a GPWS "Don't Sink" aural warning is heard. From that moment on, the stick shaker is heard continuously until the end of the recording.

At 14 h 15 min 15, a second GPWS "Don't Sink" aural warning is heard. The two recorders stopped just after that. The airplane's height in relation to the runway 02 threshold was then 335 ft, its speed was 126 kt and its magnetic heading 005°.

1.12 Wreckage and Impact Information

1.12.1 Examination of the site

The take-off area is estimated to be abeam the Tower, just after the taxiway. Practically from this point onwards, engine debris was found. Around six hundred meters before the end of the runway, the debris was scattered to the left of the centerline, showing a track roughly fifteen degrees from the centerline. The first point of impact is at 1,645 m from the takeoff area. From this point on, a strip of land showing the marks of an intense fire shows the right of the track (see photo), roughly in line with the right wing. A lot of debris was found, including the engines. The airplane then crashed into the aerodrome perimeter fence and crossed the road. Beyond the road, the right main landing gear was found (without the wheels) then the main wreckage, which had pivoted towards the right.

The main wreckage was practically in one single piece, had been destroyed by fire, the right wing was folded back along the fuselage and the rear section was detached and tipped over. The wheels of the two main landing gears were found there.

1.12.2 Visual examination of the wreckage

The wreckage was almost entirely destroyed by fire.

The two horizontal stabilizers remained attached to the fin; the elevators were in place, some outer pieces missing.

The two trim tabs are connected to the elevators.

The tail cone and APU were behind the main wreckage; and showed no signs of fire with the exception of the interior part of the APU.

Measurements taken on site:

- one flap jackscrew (partial serial No 65 – 50…): fourteen threads stripped from attachment point;
- one flap jackscrew (serial No 65 – 50326-2): thirty threads stripped from attachment point;
- one flap jackscrew (reference 65-7192 665; partial serial number ..13122): fifteen threads;
- one jackscrew at wing level (reference 65-50328-5; serial No 0279) ten threads, free moving.

1.12.3 Observations in the cockpit

• Aileron trim	2.9 right wing lowered
• Rudder trim	1.25 left
• HS trim	left up 6 units right up 6.5 units
• Fuel shut-off knobs	not used
• Flap switch lever	free moving (severed cable)
• Parking brake	“Park” position

- Speedbrake controls — locked in forward position, retracted
- Fuel feed for take-off — on
- Thrust levers — free moving
- Landing gear lever — blocked in extended position

1.12.3.1 Instruments on Captain's side

None of the instruments on the Captain's side were readable.

1.12.3.2 Instruments on co-pilot's side

- Altimeter: 300 feet on the large needle, index illegible
- Standby altimeter: 4,400 feet with setting of 1016[(2)]

1.12.3.3 Center panel instruments

- Left fuel flow meter — 4,800 kg/h
- Right fuel flow meter — 200 kg/h
- Left N2 Indicator — zero on main and secondary scales
- Right N2 Indicator — 22%
- EGT left — beyond upper limit
- EGT right — below lower limit
- Left N1 Indicator — zero on principal and secondary scales
- Right N1 Indicator — zero on principal and secondary scales
- Flap position indicators — right 26° of flap - left 29° of flap

1.12.3.4 Overhead Panels

- All hydraulic switches located on the overhead panels were found in normal operational positions, with the exception of the Yaw damper found in OFF and moving freely, which happens when it is no longer energized
- Permanent starter and ignition selectors: both in FLT position
- APU: OFF position
- Air-conditioning: normal configuration for a take-off with air-conditioning on
- Fuel pumps: all six in ON position (normal configuration for the take-off with fuel in the center tank)

1.13 Medical and Pathological Information

The post-mortem examinations performed on the crew did not bring to light any evidence of medical or pathological factors related to the accident.

(2) It was not possible to determine whether this abnormal value corresponded to the display made before the flight or resulted from manipulation after the accident. (See 1.16.4.3)

1.14 The fire

The spilled fuel burst into flames on first impact with the ground. The airplane was completely ablaze when it stopped.

In accordance with the procedures, the fire fighters were on standby. They set off as soon as they noticed that the airplane was in difficulty. At the same time, the tower controller raised the alarm at 14 h 15 min 09 s, then, in accordance with the aerodrome emergency plan, he alerted the Tamanrasset fire service at 14 h 15 min 40 s. They came to reinforce the aerodrome firefighters.

Note: the commission examined various timings under the accident conditions: the minimum time to arrive at the wreckage site from the SSLIA parking lot was three minutes and fifteen seconds.

1.15 Survival Aspects

The chief flight attendant was found collapsed over the center console (inside the cockpit. The other cabin attendants as well as the passengers were in their places, with seat belts attached. The severe fire that broke out immediately after impact left them no chance of survival. Only one passenger, seated in the last row and with seat belt unattached, according to his statement, was ejected from the plane by the impact and escaped from the accident.

1.16 Tests and Research

1.16.1 Summary of witness statements

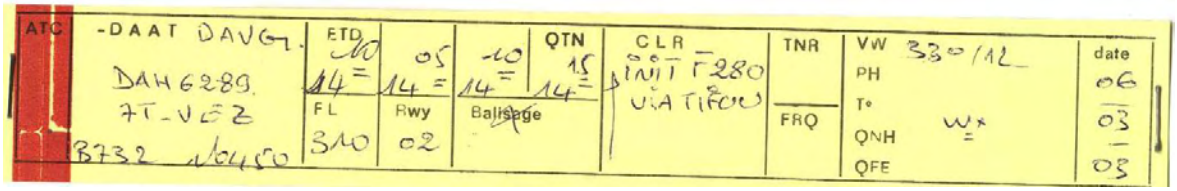
The witness statements taken indicated that at the time of take-off from runway 02, an abnormal noise coming from the airplane's engines was heard. The plane veered slightly to the left, then back towards its take-off track. During this phase, there was a sharp nose-up pitch attitude. The plane was at low altitude and seemed to be losing speed. It then dived with a slight angle to the right and crashed. The landing gear was extended.

Two witness statements are interesting to quote in full:

- That of a ground technician who worked on 7T-VEZ: *"I was on the parking lot and I saw the plane take off on runway 02. Just after the take-off, the plane swerved slightly to the left, then righted itself on the track and at that moment, I noticed that the plane was losing speed and altitude, still with its landing gear down until the moment of the crash, when there was a total explosion."*

- That of the controllers present in the tower: *"DAH 6389 B732 IMMAT: 7T-VEZ asked to be cleared for take off 1402GMT. At 1405 GMT, it was cleared for take off with a temperature of 23°, QNH: 1019.Cleared by ALGER CCR to initial FL280, just after the takeoff from runway 02 (1405) a kind of explosion was heard, the alarm was immediately activated, the pilot said we have a small*

problem. . . the plane began to fall and crashed near the threshold of runway 20; the emergency plan was immediately activated as planned. 1) Aerodrome rescue services at 1415. 2) Civil services at 1416. 3) Hospital just afterwards. Then the rest of the services mentioned in the emergency plan."



Accident flight strip

1.16.2 Preliminary examination of the engines

After the accident both of the airplane's engines and their principal accessories were transported to Brussels (Belgium) to a specialized SNECMA laboratory. There they were completely torn down. The examinations carried out led to the following observations:

- The two engines showed no uncontained failures and no indication of any fire.
- The rotating parts of the cold section of both engines showed deformations, significant on the right engine, less so on the left engine. This means that at the moment of impact with the ground, the latter was rotating at low speed, not developing any thrust.
- The hot section of the left engine had damaged components, corresponding to those found on the runway.
- The engine was not damaged a foreign object.
- The hot section of the right engine had some damaged components.

Following these observations, additional examinations were decided upon.

1.16.3 Additional examinations of the engines

Note: the following observations hereafter follow the positions of the engine components, in the direction of airflow.

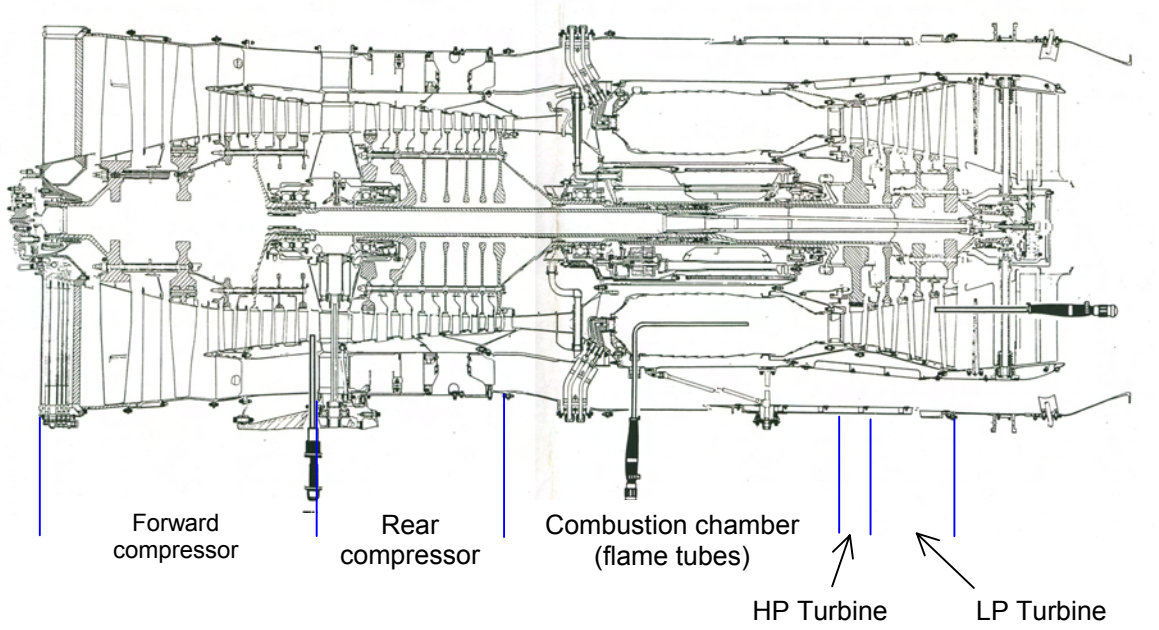


Diagram of the JT8D jet

1.16.3.1 Left engine

The compressor body
The damage observed resulted from the impact and there was no indication of engine rotation or traces of foreign body ingestion.

The FCU
The body of the regulator was destroyed on impact; it was broken and separated into three parts, with separation of the two main units along the joints. The largest part lost its covers. The different internal mechanisms made it impossible to determine selected thrust.

The fuel injectors
The nine injectors were clean and in good condition. Their output sections are geometrically correct, with no traces of burning or partial obstruction by possible foreign bodies. Their primary and secondary supply conduits showed no blockages.

The flame tubes
The outside of the tubes was in good condition, with no signs of overheating. The most notable characteristic found on the all of the tubes was traces of liquid metal on their inner walls, in rather large droplets, set on the inner thermal barrier of the tubes. These traces were all over the tubes identified as 4 to 7; on the inside of the other tubes (1, 2, 3, 8, and 9), the traces are concentrated in a sector of about 90º. The thermal barrier had normal uniform coloring.

The morphology of the metallic deposits showed that the traces were in the normal direction of gas flow.

The distributor stage (NGV 1) of the high pressure turbine
All of the nozzle guide vanes recovered from the HP turbine were severely damaged, apparently by mechanical impacts, with no signs of any previous damage. The largest missing section of the NGV1 was located in the lower part of the engine. During tear down, this part lacked its four guide vane stages.

Note: these observations are consistent with the large quantities of melted metal deposits observed on the flame tubes in the lower position (tubes No 4 to 6).

Seven blades were broken off at the root, approximately parallel with the base. The remaining blades were broken in a bell shape, the top being about halfway up, with a maximum height of forty-five millimeters. The edges of these breaks showed no signs of fatigue cracking. The lower blades, near the trailing edge, had picked up projections of melted metal. Several blades had suffered abnormally high overheating, without reaching the threshold of the metal's melting point.

The distributor stage (NGV 2) of the low pressure turbine
All of the blades of the NGV 2 stage were destroyed. The elements available showed more or less significant deposits of melted metal. The damage noted was not of the same intensity on each element; it showed that the blades were exposed to excessive temperatures; for certain blades, at least, it was possible to establish that the temperature almost reached the metal's melting point, that is to say 1,260º C.

1.16.3.2 Right engine

Note: observations carried out at the time of the right engine tear down did not show evidence of overheating that would have justified a detailed examination of the injectors. Only comparative examinations with certain components of the left engine were carried out.

The compressor body
The damage observed on the body of the compressor indicated that the engine was in rotation at the time of impact, but it was not possible to determine its selected power. No trace of ingestion of a foreign body was observed.

The FCU
The FCU unit remained in one piece. The largest part had lost several covers, sheared off or knocked off at the time of impact, exposing the mechanisms and internal components, which were damaged in various ways following the impact. Its condition made it impossible to identify the amount of power selected.

The flame tubes
The tubes did not show any particular damage that would indicate any malfunction.

The high pressure turbine
The blades of the NGV 1 stage remained in perfect condition. Fine projections of melted metal were observed on their upper surfaces. Analysis showed that these projections were the result of contact between the compressor blades and the

opposite casing. The particles that were torn off crossed the combustion chamber to be deposited on the NGV 1.

These observations showed that the right engine was rotating at the time of impact, which is corroborated by the signs of contact observed between the NGV 1, turbine HP and NGV 2 blades.

1.16.3.3 Metallurgical analyses

Comparative metallurgical examinations were carried out on components of the left and right engines as well as on deposits of melted metal sampled from the flame tubes.

For the left engine:

- The cracks on the leading edge of the two blades of NGV 1 stage were opened in the laboratory. The surfaces of these cracks were relatively flat, without traces of corrosion or of burnt erosion. The cracks are in part hidden by deposits of old coke. The cracks are the result of thermal fatigue, which existed before the event.

- The melted metal projections sampled from various elements of the hot sections of the engine (from the interior of the NGV 2 flame tubes) all came from melted blades in NGV 2. Analysis confirmed that these projections were deposited into the flames tubes, up to the neighborhood of the injectors.

- Micrographic examinations showed that the structure of the high pressure turbine blades had aging material, due to very high operating time.

For the right engine:

- Certain sectors of the NGV 2 distributor showed distinct aging, with the appearance and development of corrosion from heat on their inner walls. The progressive spread of this oxidation through sound metal provoked fine cracks on some blades, without modifying the engine's performance.

1.16.3.4 Debris recovered from the left engine LP casing and the runway

Debris of various sizes recovered from the left engine low pressure casing and from the runway mainly came from the destroyed blades from the first stage high pressure distributor as well as the upstream part of the engine.

These fragments were all transported by the rotating parts and were subject to a lot of shocks at the time of the event. The broken surfaces are mainly matt, which made any examination of the ruptures impossible.

1.16.3.5 Summary of results

The examinations of the left engine and the debris found on the runway showed that the problem stemmed from the HP part of the turbine. The part backing the LP turbine was consequently destroyed, which accentuated the loss of power and led to a sharp drop in engine rotation speed. The damage to the blades confirmed a slow rate of engine rotation at the moment of impact.

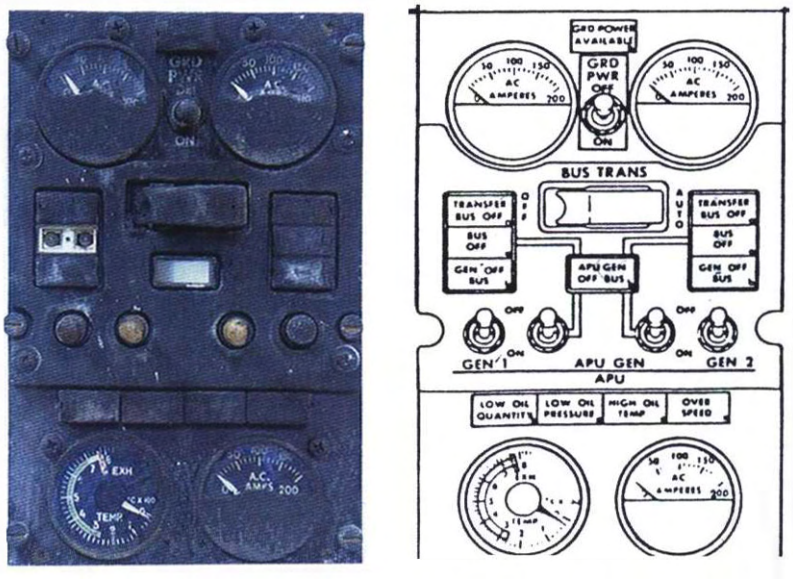
The absence of a part of the distributor and the immediate destruction of the HP turbine blades stopped the expansion of gas normally produced by the HP stage, which, in turn, prevented the cooling triggered by the gas leaving the combustion chamber. Next, excessive temperatures rapidly melted the NGV 2 part of the low pressure spool, which was then directly exposed to the heat of the combustion chamber. The melted metal projections observed in the flame tubes and the other hot sections of the engine showed that the combustion chamber was functioning at the moment of impact.

1.16.4 Examination of the equipment, flight instruments and warning lights

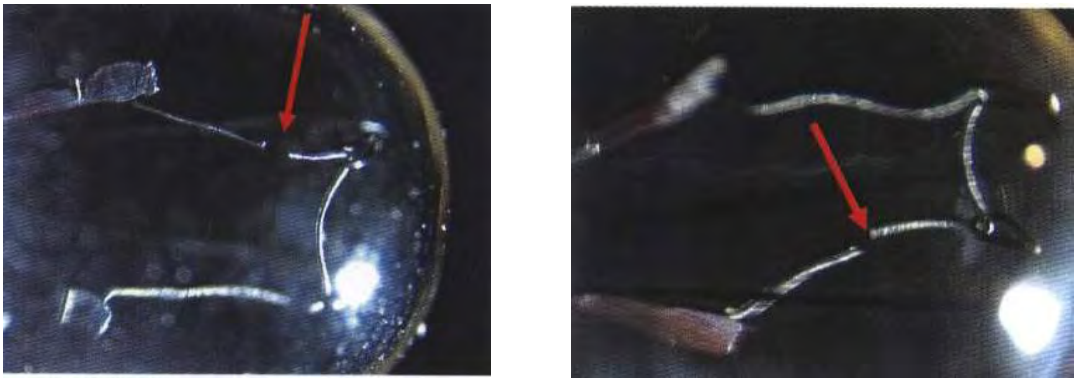
All of the instruments and equipment recovered that correspond to flight systems, electrical and hydraulic systems and engine control were removed and examined in the laboratory.

1.16.4.1 Electrical power system

Examination of the electrical power system did not bring to light any malfunction. The photo below, accompanied by the graphic from the airplane manual, shows the module related to electrical power generating systems linked to the two generators and to the APU.



The bulbs of several warning lights, including the TRANSFER BUS OFF, BUS OFF, GEN OFF BUS and APU GEN OFF BUS, were examined as the following photos illustrate. Their examination showed that most of the filaments were broken on impact.



Warning lights GEN #1 TRANSFER BUS OFF and GEN #2 TRANSFER BUS OFF

1.16.4.2 Warning lights

Examination of the bulbs of the warning lights did not show whether they were lit at the moment of impact.

1.16.4.3 Flight Instruments and equipment

Most of the equipment and flight instruments could be examined in the laboratory. Although blackened by the fire, they were, in general, in good external condition with few deformations. The values noted essentially confirm the values found on the site, though this does not necessarily prove the relevance of the display. Manipulation of the instruments had, however, modified certain values that were therefore discarded.

- EPR left engine (needle) 0.985 (flagged)
- EPR left engine (index) 2.176 (flagged)
- EPR right engine (needle) 1.0 (flagged)
- EPR right engine (index) 2.178 (flagged)
- Fuel flow meter left engine 5,400 kg/h
- Right engine fuel flow meter < 200 kg/h
- Left tank fuel quantity 4,400 kg
- Center tank fuel quantity 820 kg
- Right tank fuel quantity 4,400 kg

Note: the quantities read correspond to a weight of 9,620 kg. By adding taxiing allowance (200 kg) and the fuel consumed on take-off (225 kg), on the basis of nine tons per minute, a value of 10,045 kg is reached, consistent with the weight of on-board fuel.

- EGT left — beyond the upper limit
- EGT right — 0
- N2 left Indicator — zero on principal and secondary scales
- N2 right Indicator — 22 on principal scale, 2.5 on secondary scale
- N1 Indicator left — zero on principal and secondary scales
- N1 right Indicator — zero on principal and secondary scales.
- Electrical altimeter — setting at 1016 mb
- ADF RMI left — heading of 005°; the two indices set at 270°

1.16.5 Airplane performance on take-off

1.16.5.1 Performance calculations

A calculation of performance was carried out in the United States (cf. appendix 5). Its goal was the calculation of certain parameters not recorded by the FDR, for example pitch, roll, and engine thrust, by correlating the following various data:

- aerodynamic, kinetic and propulsion characteristics of the B737-200;
- the CVR data (noise from the stick shaker, from the GPWS alarm and from the sharp thumping noise);
- FDR parameters;
- observations made on the wreckage (position of the flaps, of the landing gear and impact marks on the ground);
- the weight, balance and thrust at take-off and the airplane's speeds (V1, VR and V2);
- the meteorological conditions on the day.

The results of these calculations showed:

- a loss of airplane speed accompanied by a continuous nose-up pitch attitude, leading to a stall situation;
- a significant reduction of thrust on the right engine a few seconds after the loss of power on the left engine. This greatly reduced the performance of the airplane during initial climb;
- that with one engine out, and with a constant V2 (150 kt), the maximum vertical speed in the climb of the airplane is around 150 feet per minute with the landing gear down. This vertical speed rises to around 450 feet per minute when the landing gear is in retracted position.

1.16.5.2 Flight simulator session

At the request of the Commission of Inquiry, and in the presence of some of its members, several tests on a flight simulator were carried out by a qualified crew using the conditions on the day of the accident. These tests were run with a left engine failure at rotation speed. During the first test, the crew was asked to follow standard procedures. During the second and third tests, the crew was asked to

keep the landing gear down, to maintain the speed at V2 in one case and to maintain a constant pitch of 18° in the other.

From this session the following results emerged:

- a change in the magnetic heading by about fifteen degrees towards the left after correction by the crew;
- vertical climb speed between 1,000 and 2,000 ft/min when the pitch is maintained at 18° from the moment of loss of power in the left engine and with the landing gear down;
- vertical speed fluctuating between - 300 and + 300 ft/min, when the V2 speed is held constant;
- stick shaker activated between 135 and 140 kt;
- difficulty for the pilot to take the controls during the initial climb with one engine out, especially after a simulator pause comparable to a transfer of control in a critical situation.

1.17 Organizations and Management

1.17.1 Crew on Boeing 737-200 by Air Algérie

1.17.1.1 Typical type rating training course

The course has in three main phases that cover:

- theoretical aspects;
- simulator sessions (Full Flight Simulator - FFS);
- in-flight sessions.

The first phase is completed by groups of about ten people and lasts eleven days. It is made up of sixty-five hours of lectures based in particular on the utilization of training documents. These theoretical courses include:

- study of airplane systems;
- study of both normal and emergency procedures;
- aspects of CRM;
- aspects of safety and rescue.

Visualization of the layout of the controls is supported by visits to the simulator. The study of each system is completed by a debriefing by an instructor responsible for technical follow-up of the Boeing 737-200. This debriefing allows for significant points to be clarified and checks the level of knowledge acquired. The final two days are dedicated to aspects of CRM and to aspects of safety and rescue.

The second phase is open to trainees who have passed the relevant exam in the theoretical section. It is made up of fourteen sessions of four hours each in the FFS simulator, carried out as a crew under the direction of a pilot-instructor,

preceded by a briefing in the auditorium of about two hours and followed by a debriefing. These sessions concern basic flying and flying on autopilot. Students study the flight envelope limits, various failures and emergency situations.

At the conclusion of these FFS sessions, a final exam lasting four hours is taken that covers the different types of problems and failures studied during the fourteen sessions.

In the context of this type rating training course, engine failure is tackled in the sixth session. Failures are generally simulated around V1 speed when the plane is rolling for takeoff. Three types can be simulated: engine flame out, damage to the engine (engine severe damage fire) and a surge.

Note: the procedure to follow after an engine failure on take-off after V1 is included in appendix 6.

The third phase (called base training) involves three flights of one hour and thirty minutes each followed by a test flight of one hour and thirty minutes, which leads to type rating certification on this model. Engine failure after V1 is included in the second and third flights as well as for the test flight.

Air Algérie's program is based on a total of thirty-one days training (including exams).

Following successful type rating, a minimum of six legs is required on line flight training before the test flight.

1.17.1.2 Recurrent training and checks

Regulatory requirements concerning recurrent training and checks are: an annual recurrent course, two annual line checks carried out during a commercial flight and related to flying skills and application of Operations Manual requirements, an annual base check (on simulator) with emphasis on type rating exercises.

Air Algérie has included, in a single module, a recurrent training course and a base check. This takes place once per year. The program for this training course was approved by the DACM. The objective of this training course is to update pilots' knowledge of the Boeing 737-200, as well as their know-how in crew task-sharing. This sometimes provides the opportunity to take into account incidents that occurred during operations, and to revise both normal and emergency procedures.

The training course lasts three days. The first is dedicated to lectures in the auditorium, and the following two to the simulator: Two sessions of four hours are preceded by a two-hour briefing. The first is carried out on the FFS simulator, in the presence of a pilot-instructor from the airline, and focuses on the regulation type rating exercises. The second session consists of a simulated LOFT-type flight at the end of which a recurrent training certificate is issued.

1.17.1.3 Crew training

The two pilots' training and recurrent training files were examined by the commission. Their last exercise in engine failure during takeoff shows:

- for the Captain, 13 January 2003. This was an exercise involving an engine fire after V1 (case of a fire being brought under control after firing two extinguishers);

- for the co-pilot, 4 November 2002. The instructor had noted that it was necessary to call out the check-list and organize the fire fighting actions.

1.17.2 Feedback system

Since 1999, Air Algérie has had a Flight Safety Office that publishes safety bulletins for crews. This office provides Aviation Safety Report forms in order to get feedback, these being available on board planes. It is also possible to inform them confidentially of concerns. The office was recently equipped with a flight analysis station dedicated to Boeing 737-600 and -800; this analysis is not yet systematic or generalized to the whole Air Algérie fleet.

The first flight safety bulletin was published in August 1999. Two or three bulletins are published every year. Each issue includes studies of accident cases or incidents based on the example of other airlines. Of the twelve issues, only five occurrences that occurred at Air Algérie were analyzed:

- the first (a British investigation report) concerned an accident that occurred on 21 December 1994 at Willenhall (Coventry) to a Boeing 737-2D6C Cargo registered 7T-VEE;
- the second related to an accident to a Boeing 727 registered 7T-VEH concerning a lateral runway excursion that occurred on 31 January 1999 at Constantine airport;
- the third concerned runway excursion by a Boeing 737-200 analyzed by a national commission of inquiry;
- the two others concern technical incidents (the beginnings of a fire in the landing gear on an A310 and an engine oil leak leading to a return to the airport).

All of the case studies described since August 2000 concern foreign operations. No event reported by an Air Algérie crew was analyzed in a written fashion.

It appears that at the time of the accident, the system for providing feedback did not develop completely or systematically, in writing, events occurring within the airline. Such systematic investigation would allow crews to benefit from the experiences of other crews reporting unusual situations, with the goal of preventing them from happening again.

2 - ANALYSIS

2.1 Accident Scenario

2.1.1 Flight preparation and takeoff roll

Flight preparation was carried out by the co-pilot alone, as the Captain arrived late. It should be noted that the Chief Flight Attendant was present in the cockpit, a fact that contributed to the checklist that the co-pilot had started being cut off after the callouts for the selected takeoff speeds.

This lack of rigor in the preparation of the flight was also noticeable during taxiing, with the failure to observe the spirit of a “sterile cockpit”. More generally, the CVR shows that at no time was there any dialogue or briefing related to a possible anomaly during takeoff, as required in the Air Algérie procedures. The crew was not apparently sufficiently psychologically prepared to face any possible problems that might occur.

Taxiing was immediately followed by engine power-up with an EPR of 2.18, which corresponds to the use of maximum thrust with the air conditioning switched on.

2.1.2 Failure of left engine during takeoff

Engine power up, airplane acceleration and the standard callouts were all carried out normally until rotation. The problems started suddenly, at the exact moment landing gear retraction was announced. All evidence gathered by the investigation, especially the airplane parts found on the runway near the place where the airplane lifted off, as well as the twelve degree change of heading to the left, show that the crew was then faced with a contained left engine burst.

Examinations showed that the problem originated in the turbine high-pressure stage located just after the combustion chamber. The rupture of a relatively large part caused the immediate destruction of the high-pressure turbine and the subsequent damage to the low-pressure turbine. The burst caused a sharp drop in the rotation speed and in engine thrust, without causing it to shut down.

Apart from the airplane’s tendency to yaw to the left, the damage to the left engine would normally result, in the cockpit, in a sudden reduction in the performance readings for that engine and a visual oil pressure warning, though without a fire alarm.

2.1.3 Management of the engine burst during initial climb

2.1.3.1 Crew coordination

The crew, which had been in a routine flight situation, was suddenly confronted with an emergency situation that required high levels of alertness, coordination and concentration, a situation for which, as previously noted, they were not specifically prepared. In this context, the Captain did not read back the order to retract the landing gear and did not retract it.

There was no announcement of the failure, no mention of any possible visual warnings such as the one associated with the oil pressure. Only a few exclamations from the co-pilot were heard. Even the callouts related to flying the airplane (speed, climb rate, trim, etc) were not made. Thus, after the failure, there was no longer any formalization of crew action, nor was there any coordination whatsoever on the management of the problem encountered.

A further factor then entered the picture: after eight seconds, the Captain took over the controls of the airplane, without any request from the co-pilot or any use of the standard terminology for handing over the controls.

It is impossible to know what led to this decision:

- did the Captain notice that the co-pilot was having difficulties controlling the airplane, or did he at least believe so?
- did he prefer to take back control, reckoning that it was his responsibility as Captain?

It is not possible to know whether his taking over the controls (words recorded on the CVR) was not preceded by an input on the controls.

In any event, the absence of any coordination between the pilots at the moment when tasks were transferred meant the Captain had to manage an emergency situation, which he had not had time to analyze completely. For the same reasons, he did not rely on the co-pilot, whom he simply asked on several occasions to let go (of the controls). He likely encountered some problems in taking over control, given that he repeated the terms “let go” and “take your hand off”, this continuing until the end of the recording. The co-pilot appears to have carried out the Captain’s orders by reading back in the affirmative and indicating her willingness to act (proposal to retract the gear, radio message to the tower with the hand mike) though without being sure of the role she was supposed to play. This may, for example, have resulted in her placing her hands on the control column at the time of the stall warning alarms, which would explain the repeated requests from the Captain. She was thus not fully carrying out her role as PNF and did not monitor or at least call out the speeds as they were decreasing. The co-pilot’s offer to retract the gear was probably not even noticed by the Captain, due to his sudden excess workload.

2.1.3.2 Maintaining climb rate

Just after the rotation, the vertical speed calculated from the FDR data was between 1,400 and 1,800 feet per minute. This can be explained by the airplane's initial speed, 160 knots, and the selection of a pitch attitude estimated at about 18°. Such a pitch angle corresponds to a climb with the engines operating nominally. The airplane's speed fell progressively.

According to the airline's procedures, the initial climb on one engine should be performed with the gear retracted, maintaining safety speed at V2 until the safety altitude. However, the landing gear was never retracted. With the conditions on the day of the accident (weight, aerodrome altitude and high temperature levels), the calculations and simulations performed show that it was difficult to maintain a positive rate of climb. Since the altitude was continuing to increase at the same rate, it was logical that there should be a progressive drop in speed.

Note: the airline's procedure corresponds to a rate of climb of around five hundred feet per minute and a pitch attitude of about twelve degrees.

The Captain took over the flight controls in a critical situation while he was out of the loop with regard to flying. This probably led him to focus on a pitch attitude that was incompatible with one failed engine. His decision to take over the controls made it impossible for him to develop and supervise a strategy to adopt for the conduct of the flight.

The left engine failure coincided with the co-pilot's request to retract the landing gear and disrupted that action. The co-pilot mentioned retracting the gear again but, at that moment, the task-sharing had been reversed. It was up to the Captain to ask for gear retraction. In the end, the gear remained extended until the impact.

The airplane's aerodynamic performance subsequently deteriorated rapidly, especially as a result of the non-retraction of the gear, which added to the effect of maintaining a high pitch attitude. In addition, it should be emphasized that the high altitude of the aerodrome and the high temperature on the day, as well as a takeoff weight close to the maximum also contributed to limiting the airplane's performance. During the initial climb, the high pitch attitude and the yaw induced by the failure of the left engine (which had the effect of increasing the drag at a critical moment), added to the factors previously mentioned.

2.1.4 Loss of control of the airplane

The high pitch attitude and the loss of speed put the airplane in a stall situation. About fourteen seconds after the noise and the "gear up" callout, the stick shaker (the device that warns the crew when 7% from the stall speed) began to operate intermittently, then continuously, until the end of the recording. The "don't sink" aural warning told the crew that the airplane was dropping. The pitch attitude was apparently maintained until impact with the ground, as examination of the site showed. On the wreckage, the horizontal stabilizer trim was found in the position for a normal takeoff, which tends to support this hypothesis.

Examinations on the site show that the rear of the airplane hit the ground first in a stall situation with a high pitch attitude. Maintaining an excessive climb angle until the accident can be explained by the Captain focusing exclusively on this parameter ("refusing" the ground in a rocky environment making an emergency landing impossible).

The shutdown of the flight recorders before impact occurred while the airplane was in a stall situation. This shutdown is related to a loss of electrical power. The Commission was unable to identify the precise cause of this loss of electrical power, which occurred in an unusual situation a very short time before the impact.

2.2 Crew Task-sharing

The above scenario shows a lack of coordination, an absence of mutual control and deviation from procedures. The problems encountered were not subject to any formalized actions by the crew. The Captain's takeover of the controls without agreement with the co-pilot, putting the latter out of the loop, occurred before the failure was identified. This sudden change destabilized task-sharing and thus crew teamwork. Management of the airplane's track and flight strategy were severely affected.

2.3 Flight Analysis and Feedback

The existing regulations do not oblige operators to analyze flights systematically. No such analysis then existed for the Boeing 737. This may help to explain the lack of follow-up in the management of conversion documents. If it had not been possible to validate them, the flight parameters for the event might not have been usable, even though they were recorded on the FDR.

This absence of flight analysis can be assimilated with the non-systematic and unwritten nature of internal feedback. Formally registering the analysis of an event in written form allows all those who might be concerned to be informed in a coherent and standardized manner; it also allows a systematic record to be kept which will not be lost in the course of time.

3 - CONCLUSIONS

3.1 Findings

- The airplane was certificated, equipped and maintained in accordance with the existing regulations.

- The airplane was airworthy. There were no deferred maintenance issues.

- The crew was trained and qualified in accordance with the requirements of Air Algérie and with the existing regulations.

- The co-pilot was pilot flying until the Captain took control.

- The weight and balance of the airplane were within the manufacturer's weight and balance envelope.

- The Chief Flight Attendant spoke directly to the Captain during flight preparation and taxiing.

- The pre-start-up and pre-takeoff checklists were not performed. The emergency procedures were not mentioned.

- The power-up and acceleration were normal.

- Rotation was performed at about 150 knots, just above the planned speed.

- Immediately after the co-pilot's request to retract the landing gear, the HP turbine on the left engine suffered a failure that led to a sudden loss of thrust and led the airplane to yaw. Landing gear retraction was not carried out, which increased drag significantly.

- Debris from the left engine was found on the runway near the area where the airplane lifted off.

- There was no communication between the Captain and the co-pilot concerning an emergency situation (identification of the nature of the problem).

- The Captain announced he was taking over the controls about eight seconds after the failure. In between times, the airplane's excess yaw had been brought under control.

- Four seconds later, the co-pilot called the control tower to say that they had a problem.

- The rate of climb was maintained, the airplane's speed dropped progressively until it reached stall speed.

- The maximum height reached by the airplane was about 400 feet above the aerodrome, about ten seconds before the end of the recording, the stick shaker being audible at that moment.

- Approximately ten seconds before the end of the recording, the “Don’t Sink” aural warning was heard.

- The FDR and CVR shut down before impact while the airplane was in a stall situation.

- The airplane’s initial impact with the ground occurred at a distance of about 1,645 m from the lift-off area, 12° to the left of the runway centerline.

- An intense fire broke out immediately. The airplane slid, losing various parts, hit and destroyed the airport boundary fence and then crossed a road before coming to a halt in flames.

- The control tower sounded the alarm. The airport fire service immediately headed towards the site of the accident.

3.2 Probable Causes

The accident was caused by the loss of an engine during a critical phase of flight, the non-retraction of the landing gear after the engine failure, and the Captain, the PNF, taking over control of the airplane before having clearly identified the problem.

The following factors probably contributed to the accident:
- the perfunctory flight preparation, which meant that the crew were not equipped to face the situation that occurred at a critical moment of the flight;

- the coincidence between the moment the failure occurred and the request to retract the landing gear;

- the speed of the event that left the crew little time to recover the situation;

- maintaining an inappropriate rate of climb, taking into account the failure of one engine;

- the absence of any teamwork after the engine failure, which led to a failure to detect and correct parameters related to the conduct of the flight (speed, rate of climb, configuration, etc.);

- the takeoff weight being close to the maximum with a high aerodrome altitude and high temperature;

- the rocky environment around the aerodrome, unsuitable for an emergency landing.

4 - RECOMMENDATIONS

The accident to 7T-VEZ brought to light failings in the area of task-sharing, joint control and handing over the controls.
Consequently, the Commission of Inquiry recommends that:

- **Air Algérie, along with other operators, ensure that their CRM-type training programs effectively heighten crew awareness of the strict respect required for handover procedures and task-sharing.**

The Commission of Inquiry recommends that:

- **The Civil Aviation and Meteorology Directorate set up an organisation to inspect the application and conformity of the procedures in training programs for flight crews.**

Considering that flight safety can only benefit from the input provided by a system of feedback entirely based on events that have occurred during operations, the Commission of Inquiry recommends that:

- **The Civil Aviation and Meteorology Directorate ensure that Air Algérie and other operators set up a flight safety program that associates feedback and the systematic analysis of flight data.**

Finally, considering the importance of a permanent dialogue on safety issues with a national feedback system, the Commission of Inquiry recommends that:

- **The Ministry of Transport set up a permanent organisation for the investigation of civil aviation accidents and incidents.**

Le Président de la Commission Nationale d'Enquête

L'INSPECTEUR GENERAL

Ahcène AFFANE

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Decision n°283/cab/M of 6 March 2003

الجمهورية الجزائرية الديمقراطية الشعبية

وزارة النقل

الوزير

الجزائر، في 06 MARS 2003

رقم : 283 د.و/م.ط.م.أ.ج

قرار يتضمن تعيين لجنة تحقيق

إن وزير النقل ،

- بمقتضى القانون رقم 06/98 المؤرخ في 03 ربيع الأول الموافق لـ 27 جوان 1998 المحدد للقواعد العامة المتعلقة بالطيران المدني لا سيما المادة رقم 94 ،
- بمقتضى المرسوم رقم 84/63 المؤرخ في 03 مارس 1963 المتضمن إنضمام الجزائر للإتفاقية المتعلقة بالطيران المدني الدولي ،
- بمقتضى المرسوم رقم 165/89 المؤرخ في 29 أوت 1989 المتعلق بصلاحيات وزير النقل ،
- بمقتضى حادث الطائرة من طراز BOEING 737 - 200 المسجلة 7T-VEZ الواقع بتاريخ 06 مارس 2003 ،

يقرر

المادة 1 : قد كونت لجنة تحقيق من أجل تعيين ظروف و أسباب الحادث الواقع بتاريخ 06 مارس 2003 للطائرة من طراز BOEING 737 - 200 المسجلة 7T-VEZ لشركة الخطوط الجوية الجزائرية بتمنراست .

المادة 2 : تتكون هذه اللجنة من :

الرئيس : - السيد عفان أحسن ، مفتش عام بوزارة النقل

نائب الرئيس : - السيد أوشالة محمد ، نائب مدير الملاحة الجوية

./.

الأعضاء : . السيد حمو محمد نبيل ، مدير فرع طيران (فريطال)

. السيد أكرور رشيد ، مدير تقني بشركة الخطوط الجوية الجزائرية

. السيد ألاد محمد ، رئيس مكتب السلامة بشركة الخطوط الجوية الجزائرية

. السيد بن حبيلاس أحمد ، مدير مساعد بشركة الخطوط الجوية الجزائرية

. السيد لوراري عبد الوهاب ، من المؤسسة الوطنية للملاحة الجوية

. السيد بمشدة بشير ، من المؤسسة الوطنية للملاحة الجوية

. السيد كريم ياسين ، من مؤسسة تسيير مصالح مطارات الجزائر

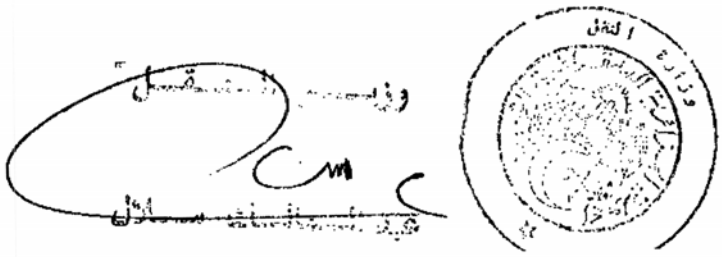
المادة 3 : يمكن توسيع هذه اللجنة بموجب قرار من طرف مدير الطيران المدني و الأرصاد الجوية لكل شخص يختار على حسب كفاءته .

المادة 4 : لأداء مهمتها ، للجنة كل الصلاحيات لدى الإدارات و المصالح المعنية للحصول على كل المعلومات اللازمة .

المادة 5 : تجتمع اللجنة بدعوة من رئيسها

تحضر اللجنة تقرير مرحلي كل خمسة عشر يوما .

المادة 6 : إن المفتش العام و مدير الطيران المدني و الأرصاد الجوية لدى وزارة النقل و المدراء العامون لشركة الخطوط الجوية الجزائرية و المؤسسة الوطنية للملاحة الجوية و مؤسسة تسيير مصالح مطارات الجزائر و مؤسسة فريطال مكلفون بتنفيذ هذا القرار .



الجمهورية الجزائرية الديمقراطية الشعبية

وزارة النقل

الوزير

06 MARS 2003

الجزائر، في

N°283/CAB.M

DECISION PORTANT INSTITUTION D'UNE COMMISSION D'ENQUETE

Le Ministre des Transports,

- Vu la loi n° 98-06 du 03 Rabie El Aouel 1419 correspondant au 27 juin 1998 fixant les règles générales relatives à l'aviation civile, notamment son article 94,
- Vu le décret n° 63-84 du 05 mars 1963, portant adhésion de la République Algérienne Démocratique et Populaire à la Convention relative à l'Aviation Civile Internationale,
- Vu le décret n° 89-165 du 29 août 1989 relatif aux attributions du Ministre des Transports,
- Vu l'accident de l'aéronef B 737-200 immatriculé 7T-VEZ survenu le 06 mars 2003,

DECIDE

Article 1 : Une commission d'enquête est instituée en vue de déterminer les circonstances et les causes de l'accident survenu le 06 mars 2003 à l'aéronef de type Boeing 737-200 immatriculé 7TVEZ de la Compagnie Air Algérie à Tamanrasset.

Article 2 : Cette commission est composée de

Président : M. AFFANE Ahcène, Inspecteur Général, Ministère des Transports,

Vice-Président : M. HOUCHALA Mohamed, Sous Directeur de la Navigation Aérienne,

Membres :

- M. HAMMOU Mohamed Nabil, Directeur Branche Aéronautique VERITAL,
- M. AKROUR Rachid, Directeur Technique Air Algérie
- M. ALLAD Mohamed, Chef Flight Safety Air Algérie
- M. BENHABYLES Ahmed, Directeur Adjoint des Opérations Air Algérie,
- M. LERARI Abdelouahab, ENNA
- M. BOUMCHEDA Bachir , ENNA
- M. KRIM Yassine, EGSA Alger

Article 3 : La composition de la commission peut être élargie par décision du Directeur de l'Aviation Civile et de la Météorologie à toute personne choisie en raison de sa compétence.

Article 4 : Dans l'accomplissement de sa mission, la commission est habilitée auprès des administrations et services concernés pour obtenir communication de tout élément d'information ou d'appréciation jugé utile

Article 5 : La commission se réunit sur convocation de son président.
La commission produira un rapport d'étape tous les 15 jours

Article 6 : L'Inspecteur Général, le Directeur de l'Aviation Civile et de la Météorologie du Ministère des Transports, les Directeurs Généraux d'Air Algérie, ENNA, EGSA Alger et VERITAL sont chargés de l'exécution de la présente décision

Transcript of radio-communications

Temps	Tour/avion	Messages
13 h 50 min 26 s	Avion	Tamanrasset rebonjour Air Algérie 6289
13 h 50 min 30 s	Tour	6289 Tamanrasset bonjour
13 h 50 min 33 s	Avion	Oui s'il vous plaît les derniers paramètres merci
13 h 50 min 37 s	Tour	Oui le vent est calme CAVOK température 23° QNH 1020 QFE 965 à vous
13 h 50 min 44 s	Avion	Copié merci je vous rappelle pour mise en route
13 h 52 min 20 s	Tour	6289 Tamanrasset
13 h 52 min 23 s	Avion	Je vous écoute
13 h 52 min 24 s	Tour	Le dernier QNH 1019
13 h 52 min 28 s	Avion	1019 reçu
13 h 56 min 21 s	Avion	Juliet Alpha d'Echo Zoulou
13 h 58 min 37 s	Avion	Juliet Alpha d'Echo Zoulou (Saut de la référence temps)
13 h 58 min 47 s	Avion	Juliet Alpha d'Echo Zoulou
14 h 01 min 37 s (+ 2 min)	Avion	Tamanrasset 6289 mise en route sur Ghardaïa s'il vous plaît (Saut de la référence temps)
14 h 03 min 21 s	Tour	Reçu on vous rappelle
14 h 03 min 23 s	Avion	Reçu
14 h 05 min 01 s	Tour	6289 Tamanrasset
14 h 05 min 03 s	Avion	Je vous écoute
14 h 05 min 04 s	Tour	Mise en route approuvée, rappelez au décollage
14 h 05 min 06 s	Avion	Reçu
14 h 08 min 32 s	Avion	Pour rouler Air Algérie 6289
14 h 08 min 36 s	Tour	6289 Tamanrasset roulez pénétrez remontez piste 02-030 degré force 10 kt

14 h 08 min 43 s	Avion	Bien reçu on roule pour la 02, on remonte reçu 6289
14 h 09 min 33 s	Tour	6289 Tamanrasset
14 h 09 min 36 s	Avion	Oui monsieur je vous écoute
14 h 09 min 38 s	Tour	De la part des opérations de Ghardaïa ils vous demandent le nombre de transitaires
14 h 09 min 42 s	Avion	Confirmez s'il vous plaît
14 h 09 min 44 s	Tour	Oui les opérations de Ghardaïa ils vous demandent le nombre de transits
14 h 09 min 49 s	Avion	Quarante passagers de transit sur Alger
14 h 09 min 52 s	Tour	Reçu
14 h 11 min 24 s	Tour	6289 Tamanrasset de la part d'Alger initialement niveau Deux Huit Zéro destination Ghardaïa Via point TIFOU
14 h 11 min 33 s	Avion	Bien reçu destination Ghardaïa initialement Deux Huit Zéro Via TIFOU Air Algérie 6289
14 h 12 min 30 s	Avion	On est paré 6289
14 h 12 min 31 s	Tour	6289 Tamanrasset autorisé à vous aligner et décoller en piste 02 - 330 en force 12 nœuds
14 h 12 min 55 s	Avion	Bien reçu on s'aligne et on décolle en piste zéro deux Air Algérie 6289
14 h 13 min 36 s	Avion	On décolle 02
14 h 13 min 40 s	Tour	Deux coups porteuse (accusé réception)
14 h 15 min 04 s	Avion	On a un petit problème 6230 …89

Remarque : les temps enregistrés sur la piste UTC présentent des variations semble-t-il aléatoires. Ils ne peuvent donc représenter une référence absolue.

CVR TRANSCRIPT

FOREWARD

The following is a transcript of the elements which were comprehensible at the time of the readout of the cockpit voice recorder (CVR) of the Boeing 737-200 registered 7T-VEZ involved in the accident at Tamanrasset on 6 March 2003. This transcript contains conversations between crew members, radiotelephonic messages and various noises corresponding, for example, to the movement of selectors or to alarms.

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

The voices of crew members are heard via the cockpit area microphone (CAM). They are placed in separate columns for reasons of clarity. One column is reserved for the voices of others, noises and alarms, also heard via the CAM.

GLOSSARY

UTC	UTC time given by the ATC center
VS	Synthetic voice
□	Communication to ATC, from the ground and from the cabin crew by interphone
example	*The words or groups of words in italics are translated from the Arabic*
( )	Words or groups of words in parentheses are doubtful
(*)	Words or groups of words not understood

Temps UTC	Commandant de bord	Copilote	Contrôle	Observation, bruit, alarme
14 h 12 min 44 s		□ On est paré soixante-deux quatre-vingt-neuf		Début de la transcription
12 min 47 s			Soixante-deux quatre-vingt-neuf Tamanrasset autorisé à vous aligner et décoller en piste zéro deux trois cent trente en force douze noeuds	
12 min 53 s		□ Bien reçu on s'aligne et on décolle en piste zéro deux Air Algérie soixante-deux quatre-vingt-neuf		
14 h 13 min 36 s		□ On décolle zéro deux		
13 min 40 s		All set for take off (…)		
13 min 42 s				Deux coups d'alternat
13 min 47 s		Autorisé		
13 min 48 s	Autorisé			
13 min 50 s	Flaps one			
13 min 51 s		Flaps one all set		
13 min 52 s	(…)	(…)		

Temps UTC	Commandant de bord	Copilote	Contrôle	Observation, bruit, alarme
13 min 55 s				Bruit de mise en puissance des moteurs
14 h 14 min 03 s		Stabilized		
14 min 09 s				Bruit en poste
14 min 10 s	Allez *laisse le partir*			
14 min 14 s	(*)			
14 min 21 s	(allez décollé)			
14 min 23 s				Bruits similaires au roulement et au mouvement d'objets
14 min 29 s		I have		
14 min 30 s	You have ninety one hundred			
14 min 41 s				Bruit métallique en poste
14 min 43 s				Bruit métallique en poste
14 min 45 s				Bruit métallique en poste
14 min 46 s	Vee one			Bruit métallique en poste
14 min 47 s	Rotate			Bruit métallique en poste

Temps UTC	Commandant de bord	Copilote	Contrôle	Observation, bruit, alarme
14 min 48 s				Trois bruits métalliques en poste
14 min 49 s				Deux bruits métalliques en poste
14 min 51 s				
14 min 52 s		Gear up		Bruit sec et sourd juste à la fin de « gear up »
14 min 53 s		Ouh		Parole de longue durée
14 min 54 s				Changement de bruit de fond avec, au milieu, une interférence électrique sur les voies 1,2, 4
14 min 55 s		*Bismi allah Bismi allah Bismi allah*		
14 min 57 s		*Qu'est ce qui se passe*		Bruits métalliques en poste
14 min 58 s				Bruit répétitif similaire au mouvement de la roue de trim pendant une seconde
14 h 15 min 00 s	*Lâche lâche*			
15 min 01 s		*J'ai lâché j'ai lâché*		
15 min 02 s	Laisse laisse			Bruits métalliques en poste
15 min 03 s		Gear up *ou bien ah*		

Temps UTC	Commandant de bord	Copilote	Contrôle	Observation, bruit, alarme
15 min 04 s	ah	□ On a un petit problème euh soixante-deux (trente)		
15 min 06 s				Bruit similaire au stick shaker pendant une seconde
15 min 07 s		□ Quatre-vingt-neuf		
15 min 08 s	*Lâche enlève ta main*	*J'ai lâché j'ai lâché*		Bruit similaire au stick shaker pendant une demi seconde
15 min 09 s	*Enlève ta main*	*J'ai lâché*		
15 min 10 s				(VS) « Don't sink » alarme GPWS suivie d'un bruit similaire au stick shaker jusqu'à la fin de l'enregistrement
15 min 12 s		S'il vous plaît		
15 min 13 s	*Enlève ta main*			
15 min 15 s		(…)		(VS) « Don't sink »
15 min 16 s				Fin de l'enregistrement


7T-VEZ
B737, Air Algérie
6 mars 2003, Tamanrasset
VHF Keying (0= transmit)
Airspeed
OPL : "Gear up"
Attention: Comme la conversion de ce paramètre n'est pas connue, les valeurs peuvent présenter un biais
Vertical Acceleration
Heading
Altitude Fine
Attention: Comme la conversion de ce paramètre n'est pas connue, les valeurs peuvent présenter un biais
Temps UTC (hh:mm:ss)
BEA - Département Technique
Created: March 13, 2003

Boeing Submittal of Re-Creation of Air Algerie 737-200 PK631 Registry 7T-VEZ Accident Profile

Overview

The enclosed preliminary data plots present an estimate of the airplane parameters for the 737-200ADV Air Algerie accident at Tamanrasset, Algeria on March 6, 2003. The airplane had a left engine failure shortly after takeoff and subsequently crashed within the airport boundary. The estimated parameters were derived from the flight data recorder (FDR) and cockpit voice recorder (CVR) information using an optimization analysis approach. This analysis approach achieved good fidelity with the recorded information.

The airspeed decreased on the airplane to the point that a stall condition was encountered. In addition, our analysis of the FDR and CVR data concludes that a significant reduction in thrust on the right engine occurred after the failure of the left engine.

Discussion

Background of Available Data

The PK631 FDR had 6 data parameters recorded: time, altitude, airspeed, magnetic heading, normal load factor, and VHF keying. The load factor signal was found to be inverted and was corrected. The CVR provided the sounds of stick shaker, Ground Proximity Warning System (GPWS) warnings, and a loud bang thought to be from the left engine failure. GPWS on the 737-200ADV uses the indicated altitude to generate the "don't sink" warning.

The factual findings from the wreckage examination support that the flaps remained at the flaps '1' setting and that the gear was down throughout the flight. The factual findings also provided the takeoff weight, center of gravity, takeoff EPR, takeoff speeds, and the reported wind speed and direction. Global Positioning System (GPS) way points of the runway and impact site were used to determine the impact point. The impact marks suggest that the aft body, main gear, and right engine contacted the ground first.

Review of Re-creation

The re-creation is presented in Figures 1-3 for the time where the airplane is airborne to the time when the FDR and CVR stop recording. The FDR and CVR cease to record while the airplane is still in the air. The method for calculating this re-creation is described under Analysis Methodology.

On Figure 1, the longitudinal parameters are plotted. The re-creation of the indicated (recorded) altitude provides an excellent match of the FDR trace. The re-creation's calculation of actual altitude is shown as well and it indicates a decreasing altitude after ~100 seconds. The deviation between the indicated altitude and the actual altitude is due to errors in pressure measurements (known as "position error") that can become quite large when the airplane enters a stall. The re-creation also provides a good match of the FDR airspeed. The airspeed decreases after the left engine failure, to the point that a stall condition is reached. Given that the airspeed and altitude are decreasing simultaneously, the airplane had severely degraded performance relative to a "normal" engine-out condition.

The thrust time history for the left engine failure was assumed to be similar to that of a fuel cut. A rapid decline in thrust occurring a half a second before the loud bank heard on the CVR is consistent with the heading change and performance of the airplane. The right engine thrust is the calculated value that is required to achieve the airplane altitude and airspeed. To achieve the accident profile, the right engine thrust had to be significantly decreased. Note that if the left engine was continuing to provide some minimal amount of thrust after the failure, the calculated right engine thrust would have to decrease further to maintain the match of the airplane performance.

The calculated pitch attitude initially achieves an angle of 16-18 degrees which is consistent with an all-engine takeoff but not for a single engine takeoff. The calculated angle-of-attack shows the airplane approaching a stall and recovering at 102 seconds and then entering a full stall around 108 seconds. This is generally consistent with the stick shaker actuation heard on the CVR. The calculated elevator is within the airplane's capability.

On Figure 2, the lateral-directional parameters are plotted. A good match of magnetic heading is achieved. Due to the limited information available, there is not one unique solution for the lateral-directional axis. Two solutions are provided to illustrate the different potential answers for the lateral-directional axis; one allows a very oscillatory behavior and the other one is less oscillatory. However, the uncertainties of the lateral-directional parameters do not have a significant impact on the longitudinal results.

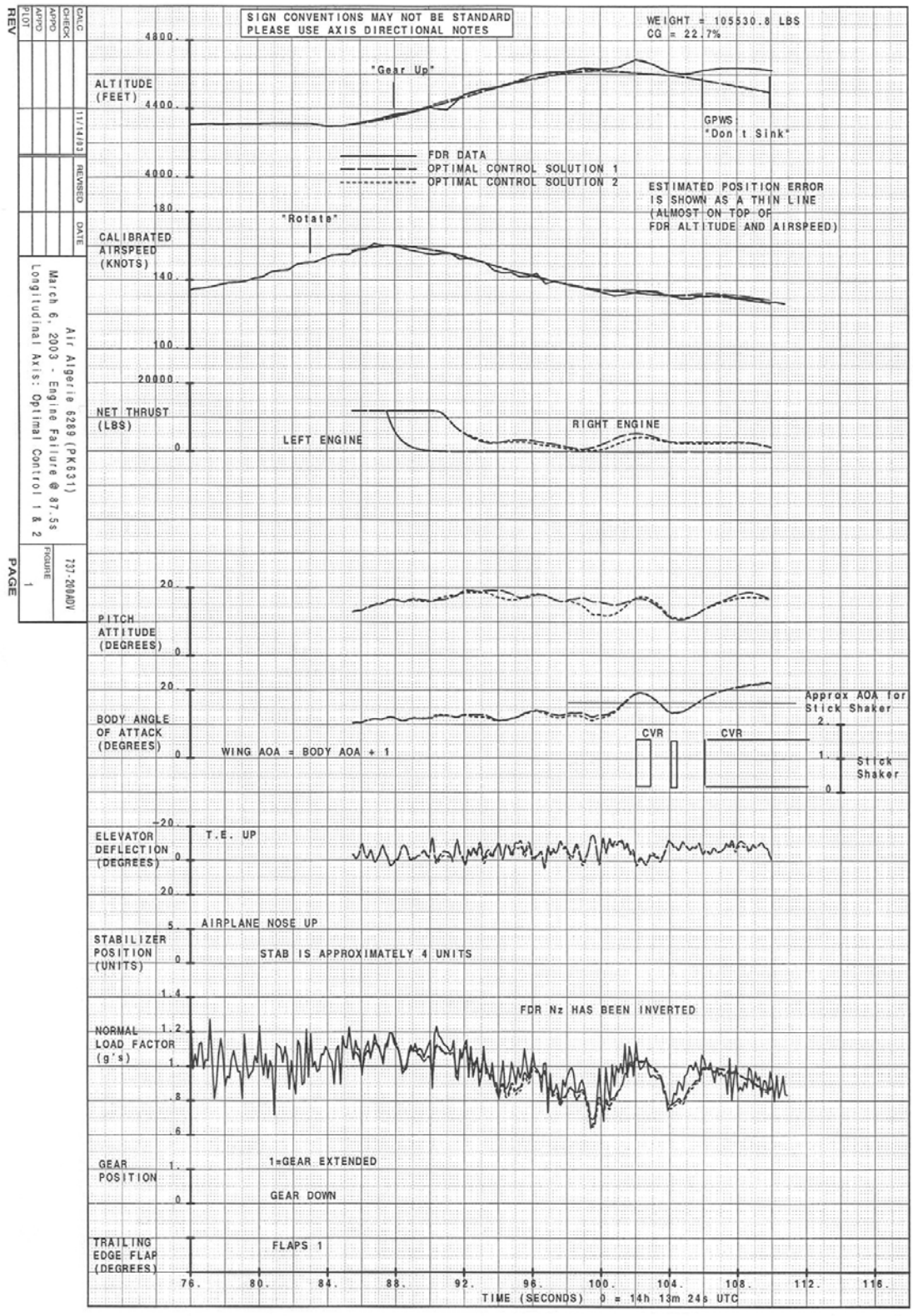
Figure 3 illustrates key parameters plotted versus distance along the runway. When the altitude is extrapolated to the altitude at ground impact (approximately 50 feet above the runway), the re-creation of the accident will impact in close vicinity to the accident impact site. The re-creation will also impact at an airplane attitude consistent with the impact marks from the aft fuselage and gear.

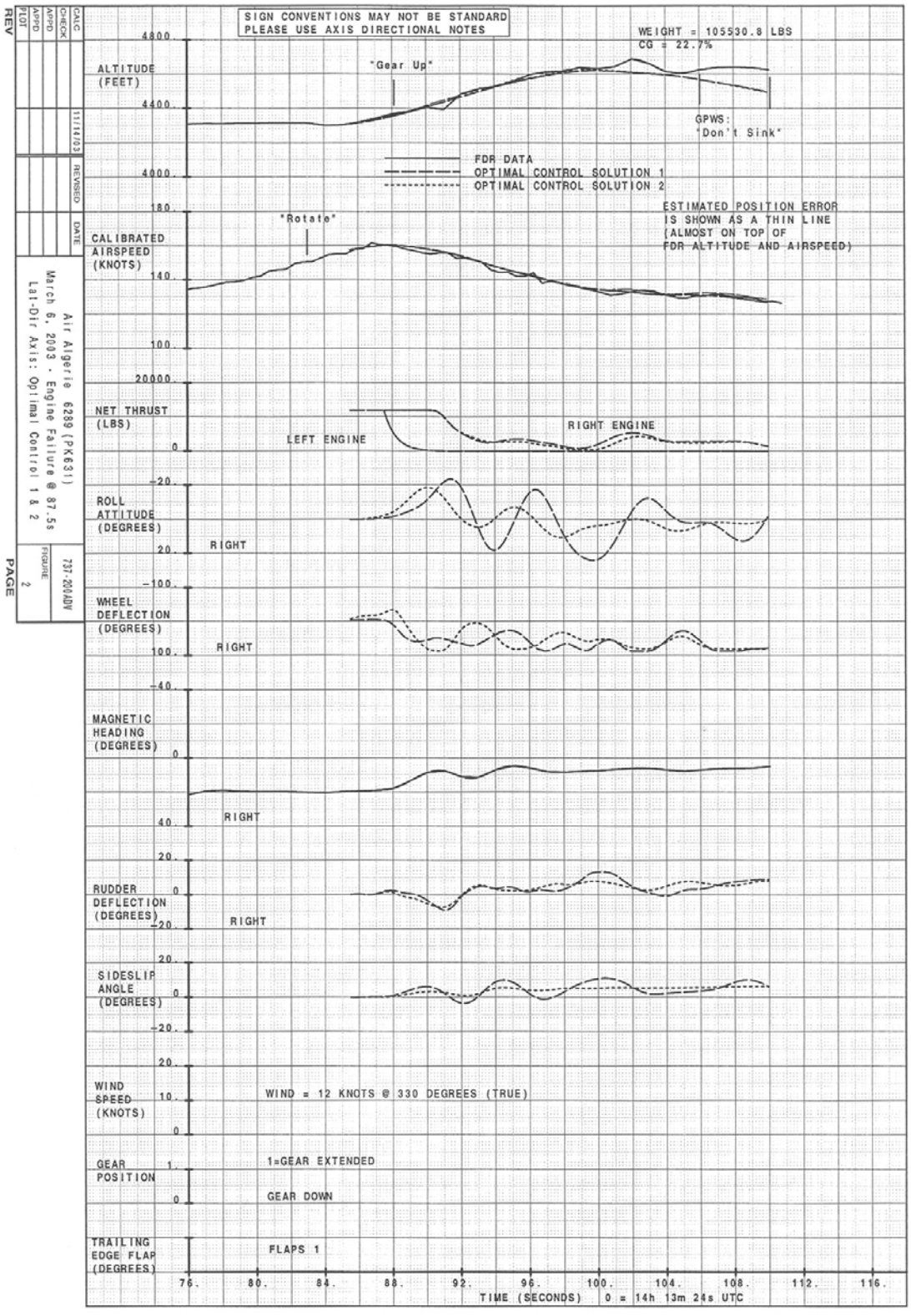
Analysis Methodology

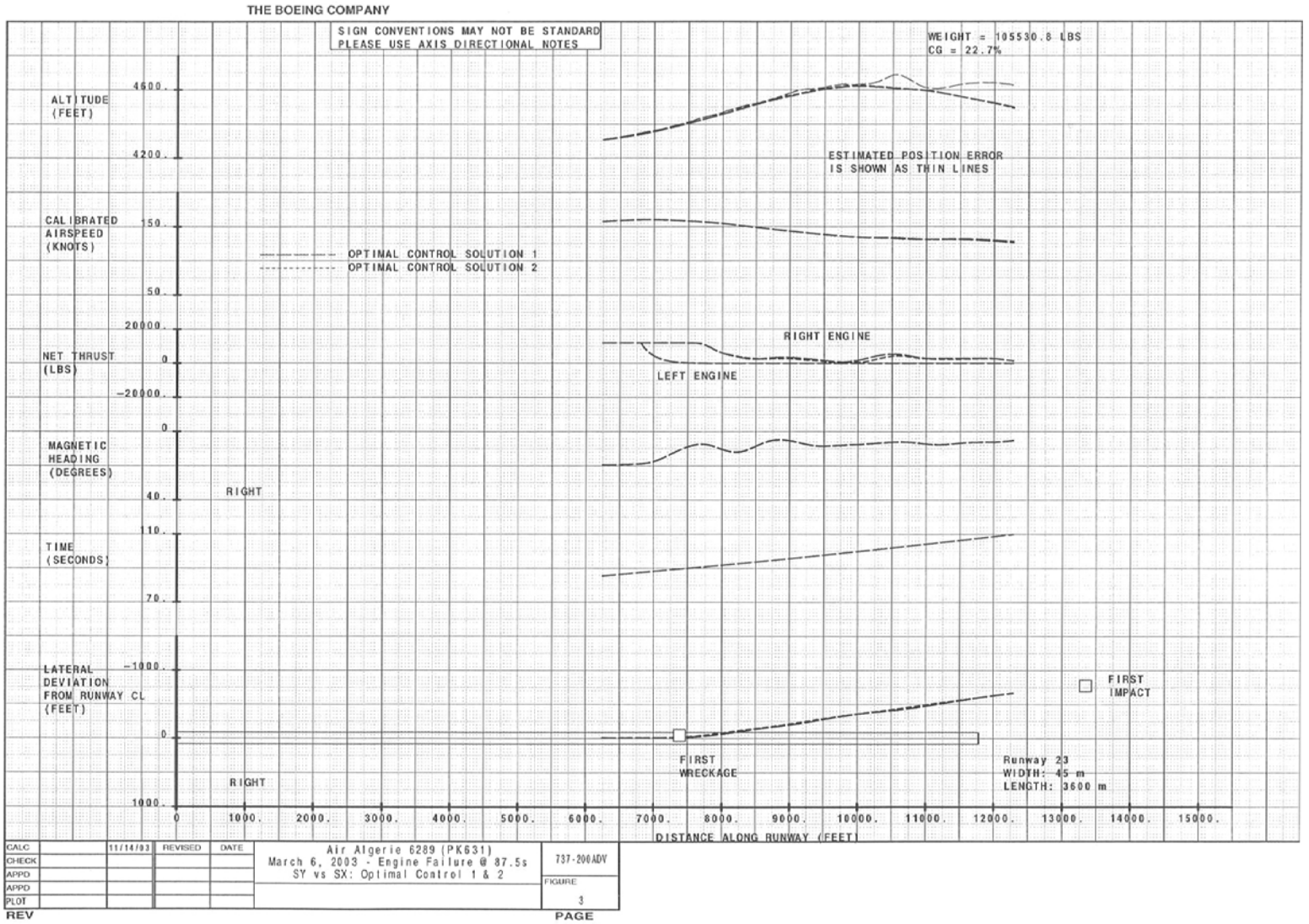
The estimated airplane parameters were derived using an optimization analysis approach. The airplane flight dynamics employed in the optimization approach include airplane kinematics, aerodynamics and propulsion as modeled by the 737-200 ADV Boeing engineering simulator. Since the optimization process requires that the 1st and 2nd derivatives of the dynamic models be continuous, the existing engineering simulator aerodynamic tables were converted to splines. Estimated position errors in pressure altitude and airspeed as functions of angle of attack were also included to correct the recorded altitude and airspeed. Based on information from the cockpit voice recorder (CVR), it was concluded that the left engine failed shortly after liftoff, and an assumed fuel cut thrust profile for this engine was generated using the simulator. In the optimization process, 4 inputs (right engine thrust, elevator, wheel and rudder) were derived to minimize an objective function. This objective function is designed to simultaneously minimize the differences between the recorded 4 FDR parameters and the corresponding parameters from integration of the airplane dynamic equations over the time period of interest. This optimization approach has been verified using a set of simulator data at the FDR sample rates and by driving the simulation to recreate an optimized solution.

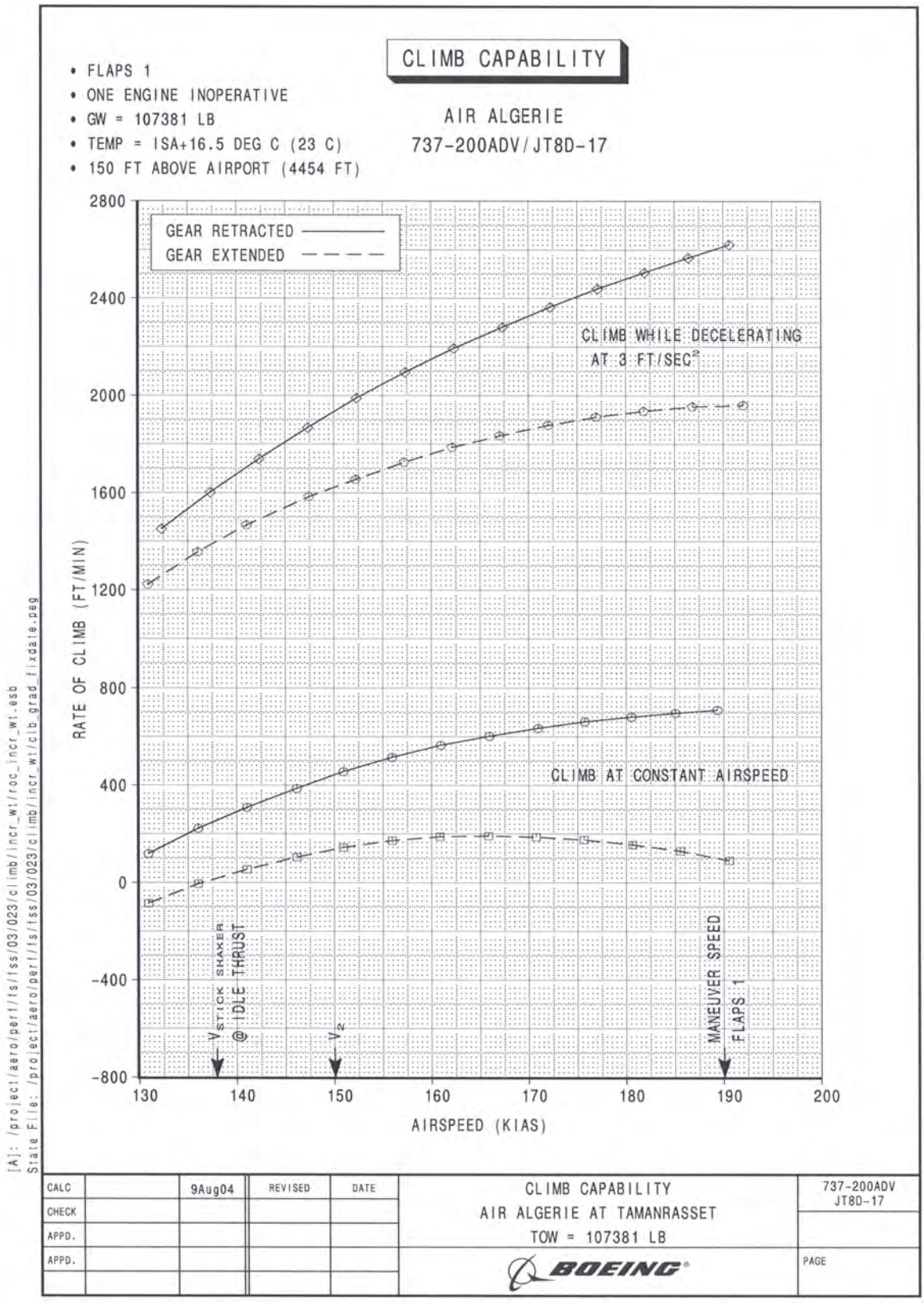
Conclusion

The re-creation provides a good representation of the FDR data, CVR information, and the impact sites and impact attitude. Note that it takes a significant reduction in airplane performance, provided by the significant reduction of thrust on the right engine (in addition to the left engine failure), to achieve these results. In addition, the airspeed decreased on the airplane to the point that a stall condition was encountered.


SIGN CONVENTIONS MAY NOT BE STANDARD
PLEASE USE AXIS DIRECTIONAL NOTES
WEIGHT = 105530.8 LBS
CG = 22.7%
ALTITUDE (FEET)
4800.
4400.
4000.
"Gear Up"
GPWS "Don t Sink"
FDR DATA
OPTIMAL CONTROL SOLUTION 1
OPTIMAL CONTROL SOLUTION 2
ESTIMATED POSITION ERROR IS SHOWN AS A THIN LINE (ALMOST ON TOP OF FDR ALTITUDE AND AIRSPEED)
CALIBRATED AIRSPEED (KNOTS)
180.
140.
100.
"Rotate"
NET THRUST (LBS)
20000.
0
LEFT ENGINE
RIGHT ENGINE
PITCH ATTITUDE (DEGREES)
20.
0
BODY ANGLE OF ATTACK (DEGREES)
WING AOA = BODY AOA + 1
CVR
CVR
Approx AOA for Stick Shaker
2.
1.
0
Stick Shaker
ELEVATOR DEFLECTION (DEGREES)
-20.
T.E. UP
20.
STABILIZER POSITION (UNITS)
5.
AIRPLANE NOSE UP
STAB IS APPROXIMATELY 4 UNITS
NORMAL LOAD FACTOR (g's)
1.4
1.2
1.
.8
.6
FDR Nz HAS BEEN INVERTED
GEAR POSITION
1.
1=GEAR EXTENDED
GEAR DOWN
TRAILING EDGE FLAP (DEGREES)
FLAPS 1
76.
80.
84.
88.
92.
96.
100.
104.
108.
112.
116.
TIME (SECONDS) 0 = 14h 13m 24s UTC
REV
PLOT
APPD
CHECK
APPD
CALC
11/14/03
REVISED
DATE
Air Algerie 6289 (PK631)
March 6, 2003 - Engine Failure @ 87.5s
Longitudinal Axis: Optimal Control 1 & 2
FIGURE
1
737-200ADV
PAGE
THE BOEING COMPANY


SIGN CONVENTIONS MAY NOT BE STANDARD
PLEASE USE AXIS DIRECTIONAL NOTES
WEIGHT = 105530.8 LBS
CG = 22.7%
ALTITUDE (FEET)
"Gear Up"
GPWS: "Don't Sink"
FDR DATA
OPTIMAL CONTROL SOLUTION 1
OPTIMAL CONTROL SOLUTION 2
ESTIMATED POSITION ERROR IS SHOWN AS A THIN LINE (ALMOST ON TOP OF FDR ALTITUDE AND AIRSPEED)
"Rotate"
CALIBRATED AIRSPEED (KNOTS)
NET THRUST (LBS)
LEFT ENGINE
RIGHT ENGINE
ROLL ATTITUDE (DEGREES)
RIGHT
WHEEL DEFLECTION (DEGREES)
RIGHT
MAGNETIC HEADING (DEGREES)
RIGHT
RUDDER DEFLECTION (DEGREES)
RIGHT
SIDESLIP ANGLE (DEGREES)
WIND SPEED (KNOTS)
WIND = 12 KNOTS @ 330 DEGREES (TRUE)
GEAR POSITION
1=GEAR EXTENDED
GEAR DOWN
TRAILING EDGE FLAP (DEGREES)
FLAPS 1
TIME (SECONDS)
0 = 14h 13m 24s UTC
Air Algerie 6289 (PK631)
March 6, 2003 - Engine Failure @ 87.5s
Lat-Dir Axis: Optimal Control 1 & 2
737-200ADV
FIGURE 2
PAGE
REV
CALC
CHECK
APPD
APPD
PLOT
11/14/03
REVISED
DATE
THE BOEING COMPANY


THE BOEING COMPANY
SIGN CONVENTIONS MAY NOT BE STANDARD
PLEASE USE AXIS DIRECTIONAL NOTES
WEIGHT = 105530.8 LBS
CG = 22.7%
ALTITUDE (FEET)
4600.
4200.
ESTIMATED POSITION ERROR IS SHOWN AS THIN LINES
CALIBRATED AIRSPEED (KNOTS)
150.
50.
OPTIMAL CONTROL SOLUTION 1
OPTIMAL CONTROL SOLUTION 2
20000.
NET THRUST (LBS)
0
-20000.
RIGHT ENGINE
LEFT ENGINE
0
MAGNETIC HEADING (DEGREES)
40.
RIGHT
110.
TIME (SECONDS)
70.
-1000.
LATERAL DEVIATION FROM RUNWAY CL (FEET)
0
FIRST IMPACT
FIRST WRECKAGE
Runway 23
WIDTH: 45 m
LENGTH: 3600 m
RIGHT
1000.
0
1000.
2000.
3000.
4000.
5000.
6000.
7000.
8000.
9000.
10000.
11000.
12000.
13000.
14000.
15000.
DISTANCE ALONG RUNWAY (FEET)
CALC
CHECK
APPD
APPD
PLOT
11/14/03
REVISED
DATE
Air Algerie 6289 (PK631)
March 6, 2003 - Engine Failure @ 87.5s
SY vs SX: Optimal Control 1 & 2
737-200ADV
FIGURE
3
REV
PAGE


CLIMB CAPABILITY
• FLAPS 1
• ONE ENGINE INOPERATIVE
• GW = 107381 LB
• TEMP = ISA+16.5 DEG C (23 C)
• 150 FT ABOVE AIRPORT (4454 FT)
AIR ALGERIE
737-200ADV/JT8D-17
GEAR RETRACTED
GEAR EXTENDED
CLIMB WHILE DECELERATING AT 3 FT/SEC²
CLIMB AT CONSTANT AIRSPEED
RATE OF CLIMB (FT/MIN)
AIRSPEED (KIAS)
2800
2400
2000
1600
1200
800
400
0
-400
-800
130
140
150
160
170
180
190
200
V STICK SHAKER @ IDLE THRUST
V2
MANEUVER SPEED FLAPS 1
[A]: /project/aero/part/ts/tss/03/023/climb/incr_wt/roc_incr_wt.esb
State File: /project/aero/part/ts/tss/03/023/climb/incr_wt/clb_grad_fixdate.peg
CALC
CHECK
APPD.
APPD.
9Aug04
REVISED
DATE
CLIMB CAPABILITY
AIR ALGERIE AT TAMANRASSET
TOW = 107381 LB
737-200ADV
JT8D-17
BOEING
PAGE

Engine failure on take-off

- (737-200) FLAP 1, 2, 5, 10, 15, OR 25 AND 75,000 LB/34,020 KG TO 128,000 LB/58,060 KG GROSS WEIGHT
- (737-300) FLAP 1, 5, OR 15 AND 95,000 LB/43,092 KG TO 135,000 LB/61,236 KG GROSS WEIGHT
- (737-400) FLAP 5 OR 15 AND 95,000 LB/43,092 KG TO 150,000 LB/68,039 KG GROSS WEIGHT
- BASIC TAKEOFF SPEED SCHEDULE

	ROTATION TIMES - SECONDS	
CONDITION	737-200	737-300/400
ALL ENGINES OPERATING	5 TO 6	6 TO 7
ONE ENGINE INOPERATIVE	6 TO 9	8 TO 12

TABLE 2-2 TAKEOFF ROTATION TIMES VR TO 35 FEET

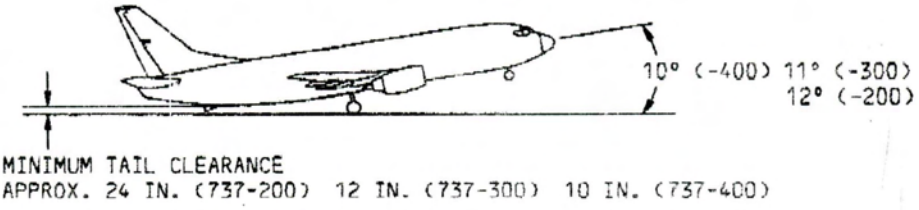


Figure 2-14 LIFTOFF BODY ATTITUDE - ONE ENGINE INOPERATIVE

Rotation

If an engine fails between V1 and lift-off, maintain directional control by smoothly applying rudder proportionate with thrust decay to maintain the desired heading or track.

Rotate normally at VR, using the required amount of control column and control wheel if necessary, to hold the wings level.

The rotation should be executed smoothly with one continuous motion. Do not rotate early or rapidly. The rate of rotation should be no faster than for a normal takeoff.

If the engine failure occurs at or after liftoff, apply aileron to momentarily establish wings level. Add rudder to center the control wheel. To center the control wheel, rudder will be required in the direction that the control wheel is displaced. This approximates a minimum drag configuration.

Initial Climb

Indicated airspeed and vertical speed are the primary instruments for pitch control after the initial target pitch attitude has been established, consequently, the initial climb attitude should be immediately adjusted to maintain a minimum of V2 and a positive climb. If an engine fails at an airspeed between V2 and V2 + 25, climb at the airspeed at which the failure occurred. If engine failure occurs above V2 + 25, increase pitch attitude in order to reduce airspeed to V2 + 25 and maintain airspeed until flap retraction altitude.

Retract the landing gear after attaining a positive rate of climb. Hold a minimum of V2 and takeoff flap setting to flap retraction altitude.

Obstacle clearance or departure clearance may require a turn shortly after takeoff. Climb performance is slightly reduced while turning but is accounted for in the airport procedure.

REPUBLIQUE ALGERIENNE
DEMOCRATIQUE ET POPULAIRE

MINISTERE DES TRANSPORTS

COMMISSION NATIONALE D'ENQUETE