



*Accident
which occurred
on 30 January 2000
in the sea near Abidjan Airport
to the Airbus 310-304
registered 5Y-BEN
operated by Kenya Airways*

REPORT

5y-n000130

FOREWORD

This report presents the conclusions of the Commission of Inquiry on the circumstances and causes of the accident that occurred on 30 January 2000 in the sea near Abidjan airport to the Airbus 310-304 registered 5Y-BEN operated by KENYA AIRWAYS, which was undertaking the Abidjan - Lagos -Nairobi flight KQ 431.

In accordance with Annex 13 of the Convention on International Civil Aviation, the conduct of the investigation is intended neither to apportion blame, nor to assess individual or collective responsibility. The sole objective is to draw lessons from this occurrence that may help to prevent future accidents or incidents

SPECIAL FOREWORD TO ENGLISH EDITION

This report has been translated and published by the BEA to make its reading easier for English-speaking people. As accurate as the translation may be, the original text issued in French by the Republic of the Ivory Coast is the work of reference.

SPECIAL NOTE REGARDING APPENDICES

The appendices available with this report are the originals. Some of them are in English while others are in French.

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Glossary

ABJ	Abidjan
AC	Auto Call Out
AD	Airworthiness Directive
ADC	Air Data Computer
AML	Aircraft Maintenance Log book
AMM	Aircraft Maintenance Manual
ANAC	National civil aviation agency (Agence nationale de l'aviation Civile)
ASECNA	Agency for civil aviation safety in Africa and Madagascar (Agence pour la Sécurité de la Navigation Aérienne en Afrique et à Madagascar)
ASNA	Abidjan nautical sports association (Association sportive nautique d'Abidjan)
BEA	French accident investigation bureau (Bureau d'Enquêtes et d'Analyses pour la sécurité de l'aviation civile)
BIMA	Infantry and marine battalion (Bataillon d'infanterie et de Marine)
BOM	Bombay
BSL	Logistical support building (Bâtiment de soutien logistique)
CCR	Regional control center (Centre de contrôle régional)
CIV	Flight information center (Centre d'information en vol)
CMD	Command
COIA	Inter-service operations center (Centre d'opérations Inter-armes)
CRC	Continuous Repetitive Chime
CTSB	Transportation Safety Board of Canada
CVR	Cockpit Voice Recorder
CWS	Control Wheel Steering
FCOM	Flight Crew Operating Manual
FD	Flight Director
FDR	Flight Data Recorder
FMC	Flight Management Computer
FMS	Flight Management System

FPV	Flight Path Vector
Ft	Feet
FWC	Flight Warning Computer
GER SMA	Abidjan underwater study and research group (Groupe d'études and de recherches sous-marines Abidjan)
GPWS	Ground Proximity Warning System
GSPM	Military fire service group (Groupement des sapeurs pompiers militaires)
ILS	Instrument Landing System
IRES	Ivorian Towing and Rescue service (Ivoirienne de remorquage et de secours)
Kt	Knots
Lb	Pounds
LOS	Lagos
MAC	Mean Aerodynamic Chord
MEL	Minimum Equipment List
NBO	Nairobi
NM	Nautical Mile (1 NM = 1.852 km)
OM	Operations Manual
P/N	Part Number
P1	Captain
P2	Copilot
PF	Pilot flying
PFD	Primary Flight Display
PISAM	Sainte Anne Marie Abidjan clinic (Polyclinique Sainte Anne Marie Abidjan)
PNF	Pilot not flying
PSI	Pounds per Square Inch
QAR	Quick Access Recorder
QFU	Runway orientation
QNH	Altimeter setting to obtain aerodrome elevation when on the ground
QRH	Quick Reference Handbook
S/N	Serial Number

SAMU	Emergency medical service (Service d'Aide Médicale d'Urgence)
SGS	General surveillance company (Société Générale de Surveillance)
SODEXAM	Society for airport, aviation and meteorological operation and development (Société d'exploitation et de développement aéroportuaire, aéronautique et météorologique)
SRS	Speed Reference System
TOGA	Take Off/Go Around
TWR	Control tower
UTC	Universal Time Coordinated
V1	Decision speed
V2	Take-off safety speed
VFE	Flaps Extended Speed
VLE	Landing Gear Extended Speed
VR	Rotation Speed
VS	Stall Speed

SYNOPSIS

Date and time

Sunday 30 January 2000
at 21 h 09 min 24 s ⁽¹⁾

Aircraft

Type: Airbus 310-304
Registration: 5Y-BEN

Site of accident

In the Atlantic Ocean 1.5 nautical miles
south of the runway at Abidjan Airport (Ivory
Coast)

Owner

Kenya Airways Limited
PO Box 19002 Nairobi (Kenya)

Geographical coordinates

Latitude: 05°13'33"28 N
Longitude: 003°56'11"73 W

Operator

The owner

Type of flight

Public transport of passengers

Persons on board: 179

2 flight crew, 8 cabin crew,
169 passengers

Flight KQ 431 ABJ-LOS-NBO

Summary

The Airbus 310 registered 5Y-BEN took off from Abidjan (Ivory Coast) bound for Lagos (Nigeria) then Nairobi (Kenya). Thirty-three seconds after take-off, the airplane crashed into the sea at 21 h 09 min 24 s.

Persons on board	Persons			Aircraft	Cargo	3 rd Party
	Killed	Injured	Unhurt			
Crew	10	0	0	Destroyed	Destroyed ⁽²⁾	-
Passengers	159	10	0			

¹ Except where otherwise noted, the times shown in this report are expressed in Universal Time Coordinated (UTC). In Ivory Coast, the legal time is UTC time.

² The cargo contained a coffin in the cargo hold.

ORGANISATION OF THE INVESTIGATION

In accordance with Annex 13 of Article 26 of the Chicago Convention, the Ivory Coast, the State of Occurrence, launched an investigation. While a Commission of Inquiry and a Technical Committee were established, legal steps were taken by the Ivory Coast civil aviation authorities as soon as the accident occurred on 30 January 2000.

Specifically, in the context of these legal steps, accident notifications were sent, in accordance with the provisions of Annex 13, to Kenya and France, respectively the State of registration and the State of Manufacture, as well as to the International Civil Aviation Organisation (ICAO).

The investigation work itself began on Monday 31 January 2000 with the establishment of several working groups made up of Ivorian, Kenyan and French investigators.

Thus, three working groups were constituted so as to find and gather the information required for the investigation in the following areas:

- operational aspects;
- air traffic aspects;
- aircraft;
- site and wreckage;
- readout of flight recorders;
- testimony;
- meteorological aspects;
- medical and pathological aspects.

The Commission of Inquiry requested that the Transport Safety Board of Canada carry out, in its laboratories in Ottawa (Canada), the readouts of the Cockpit Voice Recorder (CVR) and the Flight Data Recorder (FDR) in the presence of delegations.

Investigators undertook several missions to the Kenyan Civil Aviation Administration and to Kenya Airways in Nairobi to gather information concerning the flight crewmembers (training, qualifications, experience, physical and mental aptitude), operations, maintenance and the airworthiness of the accident airplane. Ivorian investigators visited Nairobi in March 2000, June and July 2001 and French investigators in July 2001.

At the request of the Ivorian authorities, the French BEA (Bureau d'Enquêtes et d'Analyses pour la sécurité de l'aviation civile) assisted in the search for the flight recorders, with additional work on the CVR to determine the engine speed and the identify the noises and alarms heard in the cockpit, with sonar mapping operations and with submarine operations to observe the wreckage in the accident area.

The investigative work was the subject of reports, missions abroad (Canada, France and Kenya), working meetings of the Technical committee in France Canada and the Ivory Coast and of the Commission of Inquiry in the Ivory Coast.

In accordance with the Chicago Convention, the draft final report made by the State of Occurrence was sent, for commentary, to Kenya and France before the publication of the final report.

The observations of these States were the subject of technical meetings in Abidjan from 21 to 23 January 2002, then plenary sessions of the Commission of Inquiry 24 and 25 January 2002.

At the request of its accredited representative, France's observations on the analysis of the search and rescue operations are included in an appendix to this report. Equally, at the request of its accredited representative, Kenya's observations on the search and rescue operations and on the question of TOGA are also included in an appendix.

The final investigation report was adopted on this basis. The resolution to adopt the final report was signed by the President of the Commission of Inquiry, the Accredited Representative of France and the Accredited Representative of Kenya.

The adoption report is included in Appendix 1.

The composition of the Commission of Inquiry and the Technical Committee is included in appendix 2.

1 - FACTUAL INFORMATION

1.1 History of Flight

On Sunday 30 January 2000, the Kenya Airways Airbus 310-304, registered 5Y-BEN, was undertaking the scheduled international flight KQ 431 transporting passengers from Abidjan to Nairobi, via Lagos. On board there were 10 crewmembers and 169 passengers.

On the same day, in the afternoon, 5Y-BEN had flown in from Nairobi and landed at Félix Houphouët-Boigny International Airport in Abidjan at 15 h 15. The unfavorable meteorological at Lagos had obliged the pilot, after a thirty minutes hold at Lagos, to divert to Abidjan.

The relief crew, which had arrived two days previously on flight KQ 430 on Friday 28 January 2000, at 15 h 44, took over on board 5Y-BEN, to undertake flight KQ 431 from Abidjan to Nairobi, via Lagos. Departure was scheduled for 21 h 00, in accordance with the initial program.

The copilot was pilot flying, the Captain was pilot not flying.

At 20 h 55 min 22 s, the crew established contact with Abidjan Airport control tower and asked for start-up clearance. This was granted.

At 20 h 56 min 09 s, the Captain ordered the checklist to be performed and announced the type of take-off by saying "Flex sixty" at 20 h 56 min 19 s.

At 21 h 00 min 18 s, three minutes and nineteen seconds after the start-up of the first engine (engine n° 2), the Captain announced over the interphone that linked him with the ground mechanic "we have two normal start-ups⁽³⁾".

At 21 h 01 min 07 s, the crew of 5Y-BEN asked for clearance to taxi. The tower controller put them on standby. A few seconds later, he cleared them to taxi.

At 21 h 02 min 33 s, the Captain ordered the Copilot to set the flaps at 15°. Later, at 21 h 04 min 50 s, the copilot announced "trim: 0.9 nose up, Slats/flaps 15/15".

³ The conversations recorded on the CVR were either in English or in Swahili. For convenience, all of the conversations are expressed in English in this report.

The airplane began to taxi at 21 h 07 min 35 s, the tower controller informed the crew of the latest wind, cleared them to take off and asked the crew the call back when they reached flight level 40.

At 21 h 07 min 45 s, the copilot read back the clearance. This was the last communication between the crew and the control tower.

At 21 h 08 min 08 s, the copilot announced "Take-off checklist completed ... cleared for take-off".

At 21 h 08 min 18 s, the Captain applied take-off power and announced "thrust, SRS, and runway" then, nine seconds later "100 knots".

At 21 h 08 min 50 s, the Captain announced "V1 and Rotate⁽⁴⁾", then two seconds later "Positive". The airplane took off.

At 21 h 08 min 57 s, the copilot announced "Positive rate of climb, gear up". Less than two seconds later the stall warning sounded.

At 21 h 09 min 07 s, the automatic call out (AC) announced 300 feet.

At 21 h 09 min 14 s, the copilot asked "what's the problem?".

From 21 h 09 min 16 s, the AC announced successively 200, 100, 50, 30, 20 and 10 feet.

Meanwhile, at 21 h 09 min 18 s, the copilot ordered the aural warning to be cut. Two seconds later, the GPWS sounded the "Whoop..." alarm followed, a half a second later, by the AC announcement of 50 feet.

At 21 h 09 min 22 s, an aural master warning started, immediately followed by an order from the Captain to climb: "Go up!", though this was preceded six tenths of a second by the AC announcement of 10 feet.

At 21 h 09 min 23.9 s, end of the master warning, followed immediately within a tenth of a second by the noise of the impact.

The time of the accident is presumed to be 21 h 09 min 24 s.

4 The performances of the A310-304 on the conditions on the day are V1=149 kt, VR=151 kt and V2=154 kt.

1.2 Killed and Injured

Injuries	Crewmembers	Passengers	Others
Fatal	10	159	0
Serious	0	9	0
Minor/none	0	1	0
Total	10	169	0

The list of victims by nationality is included in appendix 3.

1.3 Damage to the aircraft

The aircraft was completely destroyed on impact with the sea.

1.4 Other damage

There was no third party damage.

1.5 Personnel information

1.5.1 Flight crew

1.5.1.1 Captain

Male, aged 44

Aeronautical qualifications:

- Air Transport Pilot's License (ATPL) n° YK-650-AL issued on 10 August 1988 in Nairobi, renewed on 30 November 1999 and valid until 17 June 2000. Medical certificate, issued on 29 November 1999 and valid until 17 June 2000
- IFR rating valid until 25 April 2000
- International Radio communications Qualification n° YK-650-RL issued on 30 March 1981 in Nairobi and valid until 17 December 2001

Main type ratings: Piper 31, Piper 34, Cessna 402, DHC6 Twin Otter, Fokker 27, Fokker 50, Boeing 737-200, Boeing 737-300 and Airbus 310.

A310 type rating obtained on 10 August 1986 within Kenya Airways. The conversion course was that of Airbus Industrie, approved by the Kenyan authorities.

Professional experience before the day of the accident:

- Total flying hours: 11,636 h 20 min made up as follows:
 - 8,663 h 50 min by day and 2,972 h 30 min at night,
 - 9,917 h 40 min as Captain and 1,718 h 40 min as Copilot.
- Hours on type: 1,664 h, made up as follows:
 - 686 h 45 min by day and 977 h 15 m by night,
 - 570 h 35 min as Captain, 465 h 30 m as Captain under instruction and 627 h 55 min as Copilot
- In the previous 30 days: 67 h 55 min, all as Captain on A310.

Checks

- Last line check: 20 July 1999
- Last base check: 31 October 1999.

Previous professional experience

30 April 1984	Joined Kenya Airways as "Second Officer"
21 October 1984	Copilot on F27
27 December 1986	Copilot on A310
9 November 1988	Captain on F27 and F50
21 August 1992	Captain on B737-200
1 April 1999	Captain on B737-300
20 July 1999	Captain on A310 (training course undertaken at Airbus Training, Toulouse)

He had served as Captain on the F27, F50, B737-200, B737-300 and A310.

Experience of the route and the aerodrome

Since 15 August 1999, after obtaining his rating as Captain on A310, he had performed four landings at Abidjan Airport, on 15 August 1999, 3 October 1999, 7 January 2000 and 28 January 2000 and four take-offs, on 18 August 1999, 5 October 1999, 9 January 2000 and 30 January 2000.

Activity in the previous three days

On 28 January 2000, he had carried out the Nairobi - Lagos - Abidjan flight and flown 6 hours and 10 minutes. After a rest period of 52 hours and 45 minutes, he returned to duty to undertake flight KQ 431 Abidjan – Lagos - Nairobi with take-off scheduled for 21 h 00.

1.5.1.2 Copilot

Male, aged 43

Aeronautical qualifications

- Air Transport Pilot's License (ATPL) n°YK-1197-AL issued on 4 August 1999 in Nairobi and valid until 11 February 2000. Medical certificate, issued on 4 August 1999 and valid until 11 February 2000
- IFR rating valid until 18 June 2000
- International Radio communications Qualification n°YK-1197-RL issued on 31 March 1983 and valid until 11 February 2001

Main type ratings: McDonnell Douglas DC9 and Airbus 310.

A310 type rating obtained on March 1991 within Kenya Airways. The conversion course was that of Airbus Industrie

Professional experience before the day of the accident

- Total flying hours: 7,295 h 32 min, of which 5,699 h 42 min as Copilot and 190 h 20 m as pilot under instruction
- Hours on type: 5,768 h 47 m, of which 5,599 h 52 m as Copilot and 168 h 55 min as pilot under instruction

- In the previous 30 days: 65 h 45 min, all as Copilot on A310.

Checks

- Last line check: 29 July 1999
- Last base check: 10 October 1999.

Previous professional experience

1 March 1988	Joined Kenya Airways as "Second Officer"
8 April 1989	Copilot on DC9
11 March 1991	Copilot on A310

He had served as Copilot on DC9 and A310. He was assigned to the B 707 section, but had never qualified on that type of airplane.

Experience on the route and at the aerodrome

Since 15 August 1999, after obtaining his rating as pilot's license, he had performed four landings at Abidjan Airport, on 6 August 1999, 26 November 1999, 12 December 1999, and 28 January 2000 and four take-offs, on 8 August 1999, 5 October 1999, 28 November 1999, 16 December 1999 and 30 January 2000.

Activity in the previous three days

On 28 January 2000, he had carried out the Nairobi - Lagos - Abidjan flight and flown 6 hours and 10 minutes. After a rest period of 52 hours and 45 minutes, he returned to duty to undertake flight KQ 431 Abidjan - Lagos - Nairobi with take-off scheduled for 21 h 00.

1.5.1.3 Cabin crew

Chief Flight Attendant: male aged 39, possessing the necessary qualifications to perform his duties.

The 7 other members of the cabin crew also possessed the necessary qualifications to perform their duties.

On 28 January 2000, all of the cabin crew had undertaken the Nairobi-Lagos-Abidjan flight and flown for 6 hours and 10 minutes. After a rest period of 52 hours and 45 minutes, they went on duty again to undertake flight KQ 431 Abidjan-Lagos-Nairobi with a take-off planned for 21 h 00.

1.5.2 Maintenance Personnel (accompanying mechanic)

Male, aged 45

Aeronautical qualifications

- License n°YKC 214-AMEL issued on 20 July 1992 in Nairobi
- Transit authorization rating on A310 on 6 June 1994 in Nairobi

Previous professional experience

1974-1979	Airframe and engine course in the Kenyan Air Force and awarded a diploma as airframe and engine mechanic.
1979	Advanced course at Rolls Royce on engine changes and treatment of engine breakdowns.
1984	Joined Kenya Airways as airframe and engine mechanic.
1992	Awarded turbo engine rating (WTR)
1995	Transit authorization rating authorizing technical stopover tasks to be performed on F50
1998	Same rating on A310
1999	Complete rating on CFM56 engine (B737-300 engine)

For operations on the Nairobi - Abidjan - Nairobi route, Kenya Airways assigns an accompanying mechanic on board, whose role is to undertake technical tasks at the stopover. If required, he can request the assistance of Air Afrique mechanics. He has no operational role during the flight.

For these flights, the accompanying mechanic flies the Nairobi-Abidjan leg then returns the same day with the same aircraft on the Abidjan-Nairobi leg.

1.5.3 Air operations personnel

Aircraft coordination

Male, aged 47

Previous professional experience:

1 March 1978	Joined Air Afrique
1978	Training as operations agent
August 1979	Confirmed as TFC/OPS agent, as of 1 May 1979
1980	Training course as operations agent, aircraft coordinator and operations, module
1989	GAETAN training course
6 June 1990	Confirmed as loading manager
28 December 1994	Nomination as operations supervisor from 1 July 1994
20 September 2000	Hazmat rating training course

Station operations

Passenger and baggage check-in from Abidjan was carried out by Air Afrique personnel under the supervision of KMM personnel, Kenya Airways General Sales Agent at Abidjan. The same applied for the passengers in transit from Nairobi bound for Lagos.

Freight and baggage handling was dealt with only by agents of Air Afrique, responsible for station operations for Kenya Airways at Abidjan.

Traffic operations

The load sheets, weight and balance sheets and the passenger manifest for flight KQ 431 on 30 January 2000 were prepared by Air Afrique services.

The fuel flight plan was prepared by Kenya Airways services and passed on to the crew by KLM.

The crew was responsible for ensuring operational conformity with the airline's procedures.

1.5.4 ATC Personnel (Air traffic controller)

Male, aged 35

The air traffic controller had followed the appropriate training course and obtained a diploma as an air traffic engineer, with the ATC option, from the African School of Meteorology and Civil Aviation (EAMAC) in Niamey (Niger) in 1995.

He entered the ASECNA as a trainee controller on 1 September 1997.

He was authorized to occupy the CIV, CCR and TWR positions from 20 April 1998, 26 February 1999 and 19 June 1999 respectively at Abidjan Airport.

His activity in the previous seven days corresponded to the usual shift duty for ASECNA controllers at Abidjan, alternating duty and rest periods. On 30 January 2000, the controller came on duty at 19 h 42 after a mandatory rest period. He was aerodrome controller in the Abidjan control tower.

1.6 Aircraft information

1.6.1 Airframe

- Manufacturer: Airbus Industrie
- Type: A310-304
- Serial number: 426
- Certificate of airworthiness: n°426 dated 24 September 1986, valid until 21 December 2000, issued by the Kenyan civil aviation authorities in accordance with the export certificate of airworthiness n°13896
- Entry into service on 22 September 1986
- Flight time as of 30 January 2000: 58,115 hours
- Number of cycles as of 30 January 2000: 15,026

1.6.2 Engines

- Manufacturer: General Electric
- Type: CF6-80C2A2
- Serial number
 - Left: 690,120
 - Right: 690,141

- Flying hours as of 30 January 2000:
 - Left: 43,635
 - Right: 41,754
- Number of cycles as of 30 January 2000:
 - Left: 11,343
 - Right: 10,659

1.6.3 Equipment

5Y-BEN was equipped with the instruments and flight control systems required by international standards for aircraft for the public transport of passengers.

The airplane was equipped with:

- a Signature Emergency Locator Transmitter (ELT), type BE 369 MK2, P/N 78340, S/N 5242. This ELT, which broadcasts a signal allowing it to be located using the COSPAS SARSAT system, was probably destroyed on impact and did not work. The accident site could thus not be located using the COSPAS SARSAT system;
- an Allied Signal Ground Proximity Warning System (GPWS) d, P/N : 960-0576-002, S/N : 1002 which warns the crew of imminent contact with the ground.

The GPWS system is described in appendix 4.

There were no Service Bulletins relating to the GPWS.

1.6.4 Electrical circuit

The electrical system on the A310 is supplied in flight through 6 possible sources of electrical generation. Electrical power distribution is designed in such a way that in case of the loss of one or more sources of generation, electrical power supply can be ensured automatically or manually in the systems and circuits, according to their importance in normal and emergency maneuvers.

1.6.5 Weight and balance

The aircraft was configured for 2 flight crew, 8 cabin crew and 202 passengers (18 F and 184 Y). Under the passenger cabin there were three holds:

- a forward lower cargo hold with a capacity of 3 pallets (88 x 125) or 8 IATA-V3 or 4 IATA-V1 or 4 IATA-W3 containers or a combination of pallets and containers;
- an aft cargo hold with a capacity of 6 IATA-V3 or 3 IATA-V1 or 3 IATA-W3; and
- a bulk cargo hold for bulk merchandise.

The aircraft's horizontal stabilizer is equipped with a trim tank that allows the center of gravity to be modified, on the ground and in flight, by transferring fuel from the center tank (6,150 liters maximum, or 5,012 kg for a density of 0.815). On the ground, this transfer can be used by the crew to adjust the balance. In flight, above 20,000 feet, it is usually managed by the airplane's automatic systems in liaison with the Center of Gravity Control Computer (CGCC).

Maximum take-off weight is 153,000 kg and maximum landing weight 123,000 kg. The authorized balance range at take-off is from 20,2% to 36,5% and the authorized balance range on landing is from 20,7% to 33,8%.

A copy of the weight and balance sheet given to the crew on departure from Abidjan showed:

- a take-off weight of 127,855 kg;
- a center of gravity at 26,27% from the MAC.

1.6.6 Maintenance and airworthiness

5Y-BEN was maintained in accordance with Kenya A310 Maintenance Manual (MM) approved by the Kenyan civil aviation authorities.

1.6.6.1 Maintenance program

The MM defines a program for the airframe that provides for:

- transit checks
- pre-flight checks
- daily inspections
- weekly inspections
- STAR type inspections every 400 hours

- type A inspections(or A checks) every 550 hours or 39 days, depending on which limitation is reached first and multiples of A until check 12A. The last type A inspection (11A), was carried out on 27 January 2000 in Nairobi
- type C inspections (or C checks) every 15 months and multiples of C inspections until check 8C. The last type C (5C) inspection was carried out on 16 November 1998 in Nairobi

Approval for the inspections, referenced KA/A310/MPD dated 20 June 1988 by the Kenyan Civil Aviation Directorate does not mention the Star inspections. The frequency of the type A inspections was extended from 250 to 550 flying hours with the approval of the Kenyan civil aviation authorities, in accordance with the authorization AI/SE-T6/955 0944/94 of April 1994.

The A inspections do not appear in the aircraft's logbook. Equally, inspection 4C does not appear in the logbook either.

Type A inspections

Variations were noted in the performance of the type A inspections, since the last type 5C inspection on 16 November 1998, with 46 days between inspection 2A on 9 February 1999 and 10 days between inspection 2A on 9 February 1999 and the 3A inspection on 30 March 1999.

The last type A inspection was performed on 27 January 2000, three days before the accident.

Type C inspections

Variations between the dates in the performance of the type C inspections, between the last type 8C inspection on 08 June 1995, resulting in a new series of inspections of the same type until 16 November 1998, were 11.74 months between the 8C inspection and the 1C inspection; 5.79 months between the 1C inspection and the 2C inspection; 15.02 months between the 2C inspection and the 3C inspection and 8.78 months between the 3C inspection and the 5C inspection.

Kenya Airways stated that these inspections can be performed in advance, according to the workload and operational requirements. Thus, after the inspection in February 1998, the 4C inspection should have been performed after 15 months in May 1999, which corresponded to a year's advance in relation to normal programming. So, to cover the items on the C inspection, the 5C inspection was performed in November 1998 and the 4C inspection

1.6.6.2 Examination of equipment log

Examination of the equipment log for the 30 days preceding the accident showed crew comments relating to the following ATA chapters:

- ATA 23/34 (Communications/Navigation)
- ATA 27 (Flight controls)

- ATA 28 (Fuel)
- ATA 32 (Landing gear)

On the day of the event, the CGCC was unserviceable (see ATA 28) and the horizontal stabilizer trim tank did not contain any fuel.

A table showing the notes written in the equipment log is in appendix 5.

1.6.6.3 Maintenance log

Examination of the maintenance log for the 30 days preceding the accident showed maintenance actions performed relating to the following ATA chapters:

- ATA 25 (Equipment/installations)
- ATA 28 (Fuel)
- ATA 32 (Landing gear)

A table showing the notes written in the equipment log is in appendix 5.

1.6.6.4 Airworthiness

The Certificate of Airworthiness was regularly renewed on an annual basis by the Kenyan Civil Aviation authorities until 25 November 1999. It was extended until 21 December 1999, then renewed on 22 December 1999 until 21 December 2000.

AD 2000-007-301 (B) relating to the loss of the auto-trim function (ATA 22), whose deadline for application was set as before 31 January 2000, had not been applied by 30 January 2000, at the time of the take-off from Abidjan Airport.

Investigations showed that on the date of the accident all of the other A310-300 airplanes in the airline's fleet were up to date with that AD.

This directive relates to a trim problem with the autopilot engaged. During the accident, the autopilot was not engaged.

1.6.6.5 Technical situation of the airplane on 30 January 2000

The Commission was not able to consult the technical log sheets of flight KQ 430 on arrival of the airplane at Abidjan, nor those of flight KQ 431 on departure from Abidjan, and was unable to make any statement on the technical condition of the airplane at the time of its departure from Abidjan as flight KQ 431 on 30 January 2000. The logbook with the corresponding sheets was on board flight KQ 431 and was not found after the accident. A copy of these sheets should have been left at Abidjan before take-off. The investigation was unable to trace such a copy.

1.7 Meteorological Conditions

1.7.1 General situation

From 20 h 00 to 24 h 00, the sky was clear with few clouds, 2/8 of stratocumulus with its base at between 350 and 400 meters. The horizontal visibility was good, equal to or over 8 km. There was an absence of any rain or storm activity or any other meteorological phenomena at that time.

A satellite photo, below, shows the situation at 21 h 30 on 30 January 2000.



After midnight, the situation continued without any notable change compared to the first part of the night. However, there was a slight increase in the cloud cover (4 to 6/8 SC), stratocumulus whose base was between 300 and 400 meters.

At the time of the accident, the sky was black. In fact, on 30 January 2000 the moon rose at 01 h 39 and set at 13 h 46.

1.7.2 Situation at the aerodrome

The surface observation bulletin, valid every half hour, published by the Principal Meteorological Center (CMP) at the ASECNA in Abidjan indicated that the meteorological conditions at Abidjan Airport and in the surrounding areas on 30 January 2000, between 20 h 30 and 21 h 30 were as follows:

20:30

Wind:	250°/04 knots
Visibility:	10 kilometers
Ceiling:	2/8 SC at 390 meters
Temperature:	26° C
Dew point:	26° C
Pressure:	QNH: 1012

21:00

Wind:	250°/03 knots
Visibility:	8 kilometers
Ceiling:	Clear sky (SKC)
Temperature:	26° C
Dew point:	26° C
Pressure:	QNH: 1013

21:30

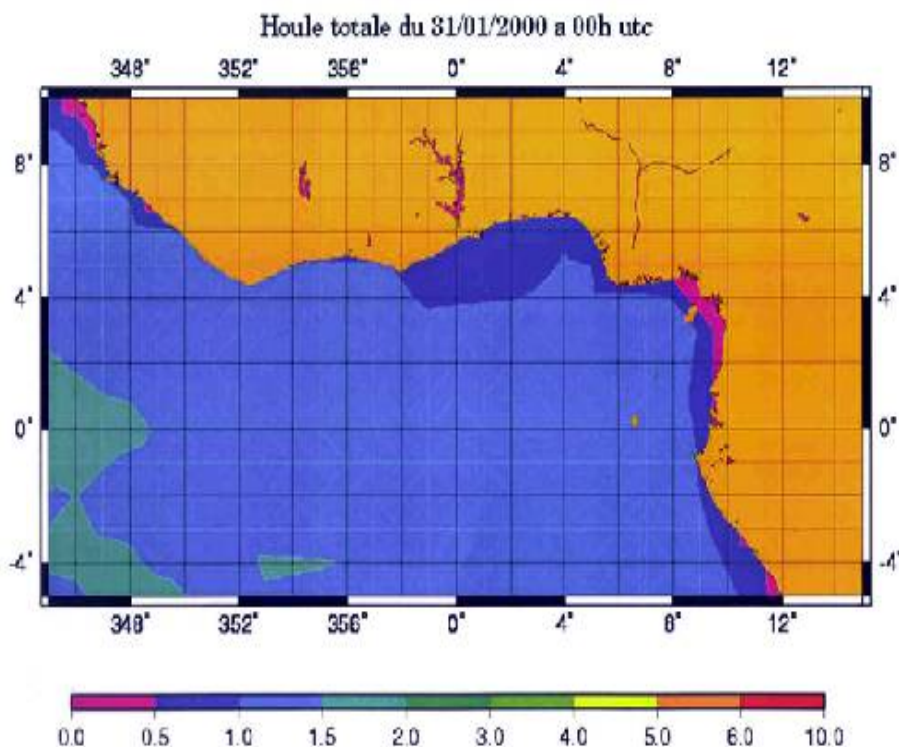
Wind: 250°/03 knots
 Visibility: 8 kilometers
 Ceiling: 2/8 SC at 390 meters
 Temperature: 26° C
 Dew point: 26° C
 Pressure: QNH: 1014

Further, the CMP did not find, during this period of time, any meteorological indications which would be particularly dangerous for aviation (storms, surface gusts, dangerous clouds, lines of squalls, etc.).

1.7.3 Maritime situation

The situation was identical to that of the continental region around Abidjan. The storm activity was centered 2 degrees latitude north and east and 2 degrees longitude west, more than 200 kilometers from the coast near Abidjan.

The satellite photo below shows the situation of the tide on 31 January 2000 at 00 h 00.



1.8 Aids to navigation

Abidjan Airport is equipped with aids to navigation such as a VOR/DME, an ILS (LOC and Glide/DME), an NDB, two Locators and a Thomson 770 RS secondary surveillance radar (SSR) under test.

The radar image of flight KQ 431 was recorded.

The airport has ground visual aids including runway lights and extended centerline approach lights for runway 21 over a distance of 900 meters.

No anomalies in these ground visual aids was reported either by the crew of flight KQ 431 or by other aircraft having used them before and after the accident. There was no connection between them and the accident.

1.9 Telecommunications

Abidjan Airport possesses VHF and HF radio communications.

The frequencies used are as follows:

- for aerodrome control: 118.10 MHZ;
- for approach control and en-route control within the TMA 121.10 MHZ;
- for en-route control within the UTA and for in-flight information:
 VHF: 129.10 MHZ,
 HF: 6586 KHZ,
 HF: 8861 KHZ.

All air-ground communications between flight KQ 431 and the Abidjan control tower, from start-up to the time of the accident, took place on the 118.10 MHZ frequency.

The air-ground radio communication equipment in service on 30 January 2000 at Abidjan Airport operated normally.

In fact, according to the readout of the magnetic tape recording of the radio communications exchanged between the control tower and flight KQ 431, radio contact was satisfactory. No operational anomalies in this equipment was reported either by the crew of flight KQ 431, or by those of other aircraft having used the equipment before and after the accident.

The transcript of the tape recording of the communications between the Tower and the crew of flight KQ 431 on 30 January 2000 is included in appendix 6.

1.10 Aerodrome information

1.10.1 Geographical situation

Abidjan Airport is located 13 kilometers southeast of Abidjan city. It is bounded by the Ebrié Lagoon to the north and the Atlantic Ocean to the south.

The geographical coordinates of the airport reference point (intersection of the runway centerline and the main taxiway) are: 05°15'16" latitude north and 003°55'43" longitude west.

1.10.2 Infrastructure

Abidjan Airport has a 03/21 runway (magnetic orientation 032°/212°) 2,700 meters long by 50 meters wide. The altitude of the runway reference point is 6 meters.

The runway has two stopways, 100 meters and 52 meters long at the QFU 21 and 03 ends respectively. It also has several taxiways.

The runway, stopway and taxiway surfaces are all covered in tarmac.

The aerodrome has night lighting. All of the obstacles are equipped with lighting systems. The runway has white runway lights, red runway end lights and green unidirectional threshold lights. The stopways have red lights. Runway 21, which is equipped for instrument approaches, has centerline approach lighting over a distance of 900 meters.

No operational anomalies were noted in the lighting, either by the crew of flight KQ 431 or by the crews of having used it before and after the accident. There was no connection between the lighting and the accident.

1.10.3 Air space

In terms of air traffic control organization, Abidjan Airport is located within a class D control region (CTR), with a vertical limit above sea and land of 900 meters and a horizontal radial limit of 15 NM. The aerodrome, approach and en-route control services are undertaken by personnel from the ASECNA.

1.10.4 Rescue and Fire Fighting Service (RFFS)

The level of protection required for Abidjan Airport is category 8, according to the ICAO classification.

On the day of the accident, the RFFS was providing level 8 protection and had the following equipment available:

- 3 medium power fire vehicles,
- 1 low power fire vehicles,
- 1 runway vehicle equipped with 50 kg of chemicals and two 5 kg CO2 extinguishers.

1.10.5 Medical service

Abidjan Airport is equipped with a medical center. The center's personnel include doctors and paramedics. The center has an ambulance. In accordance with the Abidjan Airport emergency plan, the doctors are contactable at any time in case of need.

1.10.6 Refueling

Kenya Airways has a contract with Shell for the supply of fuel for its aircraft at Abidjan.

So on 30 January 2000, Shell delivered 23,854 liters of JET A1 fuel to 5Y-BEN, or 18,870 kilos, in accordance with the delivery note.

Refueling operations began at 19 h 40 and ended at 20 h 00.

1.11 Flight recorders

1.11.1 Types and readout operations

Two mandatory flight recorders were installed on board 5Y-BEN: a CVR and an FDR.

CVR

- make: Fairchild
- model: A100 P/N TSO C84557
- serial number: 2493

FDR

- make: HONEYWELL
- model: UFDR 980-4100-DXUN
- serial number: 7172

Both models have a magnetic tape.

Readout and a test of the FDR had been carried out in TOULOUSE at Allied Signal, manufacturer of the equipment, at every other aircraft C Check, on average every 30 months. The last check had taken place on 12 September 1997. At that time, the FDR was recording a correct signal.

In the absence of FDR data, the Quick Access Recorder (QAR) was searched for during the underwater observation phase at the accident site, in case of a possible need. It was not found. Later, Kenya Airways stated that this recorder was not used by the airline, so it contained no recorded data.

1.11.2 Recovery of the flight recorders

The FDR was retrieved on 4 February 2000 about fifty meters down amongst the debris of the wreckage. It was conditioned and handed over to the airport Gendarmerie safety group (Gendarmerie du groupe de sécurité aéroportuaire). On 21 February 2000 Ivorian and Kenyan investigators took it to Ottawa to the laboratory of the Transportation Safety Board (TSB) of Canada by, where it was read out on 23 February 2000.

The FDR case had a slight impact mark on one side. The tape was intact.

The CVR was recovered on 24 February 2000 in the same bathymetric area. It was transferred to Ottawa on the same day by an Ivorian investigator. The readout was performed on arrival on 25 February 2000.

The CVR case was intact and the tape was extracted without any difficulty. The tape mechanisms and the recording tape were in good condition.

1.11.3 Data readout

1.11.3.1 CVR

The CVR recorded the last 30 minutes of the flight continuously on a loop tape.

During the readout work, the Kenyan representatives were able to identify the voices of the pilots and translate what was said from Swahili into English. A time correlation was established, by the BEA, based on the CVR readout and the recorded times of the exchanges between the airplane and the Abidjan Airport Control tower.

The transcript of the CVR recording is in appendix 7.

The following parts are of note:

Speaker	UTC	Crew conversations and noises heard
commentary	21:08:18,1	[start of engine spool up]
P1	21:08:18,4	Thrust SRS and runway
P2	21:08:20,8	Checks
commentary	21:08:21,9	[CAM level increases significantly, intermittently at first]
P2	21:08:28,7	(..... ⁽⁵⁾)
P1	21:08:29,0	Take off power is set
P2	21:08:30,4	Okay
P1	21:08:37,1	One hundred knots
P2	21:08:37,8	Checks
P1	21:08:50,7	V one and rotate
commentary	21:08:55,1	[mechanical sound transmitted through the structure (recorded only on the CAM) consistent with normal nose gear extension]
commentary	21:08:56,1	[click sound consistent with trim switch]
P1	21:08:56,7	Positive
commentary	21:08:57,2	[subtle click]
P2	21:08:57,4	Positive rate of climb, gear up
commentary	21:08:59,1	[Start of audible stall warning]

5 Unintelligible

Speaker	UTC	Crew conversations and noises heard
commentary	21:09:00,4	[unidentified noise for approximately two seconds]
P1	21:09:03,7	uhhoo [exclamation/surprise/stress]
AC	21:09:07,8	three hundred
P2	21:09:10,9	ahhh?
P2	21:09:14,0	what's the problem?
AC	21:09:15,8	two hundred
commentary	21:09:16,1	[amplitude of CAM reduces for 0,2 second - possible physical tape damage]
P2	21:09:18,5	silence the horn
AC	21:09:19,3	One hundred
commentary	21:09:20,3	[end of audible stall warning]
commentary	21:09:20,9	[blip sound, consistent with first 50 milliseconds of a "whoop ..." from GPWS]
AC	21:09:21,4	Fifty
AC	21:09:22,1	(for ... [possibly truncating forty])
AC	21:09:22,5	thir ... [possibly truncating thirty], twenty ... ten
commentary	21:09:22,5	[start of continuous repetitive chime - master warning]
P1	21:09:22,9	go up!
commentary	21:09:23,9	[end of continuous repetitive chime - master warning]
commentary	21:09:24,0	[first sound of impact]
commentary	21:09:27,6	[end of recording]

1.11.3.2 Flight Data Recorder (FDR)

Data corresponding to a series of 0's and 1's was recorded but these do not correspond to flight parameters.

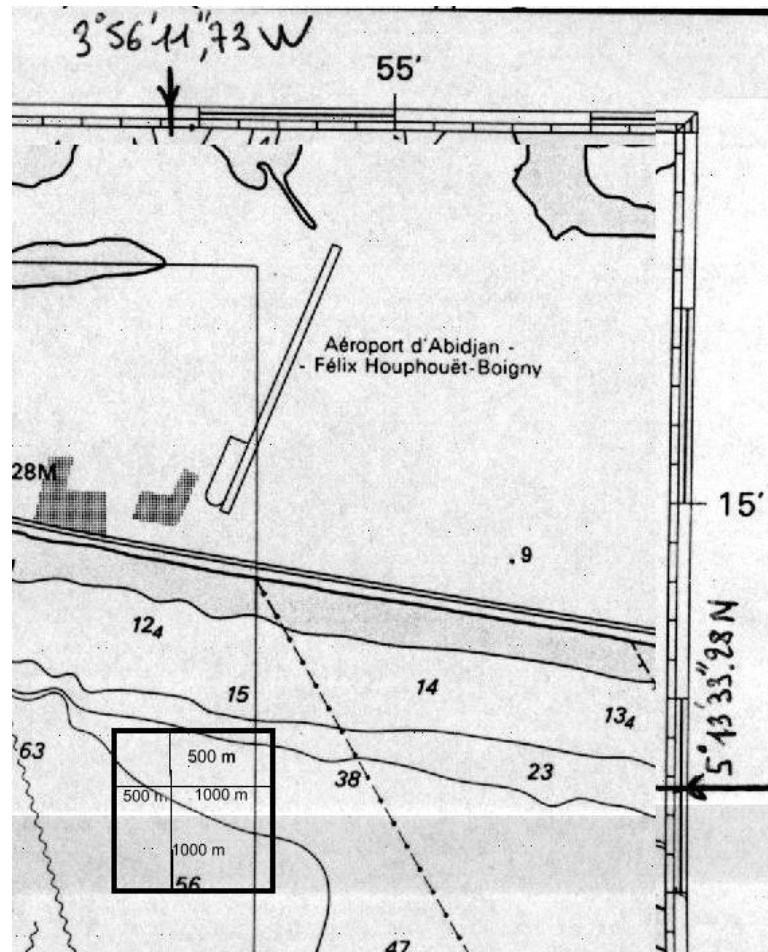
Consequently, this recorder could not be used by the Commission of Inquiry in determining the cause of the accident.

1.12 Wreckage and impact information

Information on the wreckage was collected by observation of the parts found on the beach or recovered from the sea as well as by a sonar cartography operation and underwater films of the wreckage.

1.12.1 Description of site and site plan

The impact occurred 1.5 NM from the Abidjan runway on the Atlantic Ocean. Debris from the wreckage was spread over an area 150 meters wide (east to west) by 450 meters long (north to south), at depths between 40 and 50 meters. The wreckage came to rest on the sandy seabed and was subject to a sea current from west to east.



The 1.5 square on the site plan above corresponds to the wreckage search area. The inner rectangle delineates the area where most of the debris was found.

The detail on the wreckage distribution map, within the rectangle, gives the dimensions of the debris as identified during the sonar location phase (appendix 8).

1.12.2 Significant information from the wreckage

The fin and half of the main landing gear were among the debris recovered on the surface and on the beach.

Films of the wreckage showed the following elements:

- a slat with its guide rail,
- a flap with the actuator screw jack,
- the trimmable stabilizer with the actuator screw jack,
- a landing gear assembly with its shock absorber,
- both engines,
- the cockpit center console.

The photo of these elements is in appendix 9.

1.13 Medical and pathological information

There were 179 people on board the aircraft, 169 passengers and 10 crew members.

The accident caused 169 fatalities. Of these, 146 bodies were recovered and 23 were never found.

1.13.1 Injured persons

Twelve (12) survivors, who were all passengers, were found on the night of the accident. Two (2) of the survivors subsequently died.

Of the 10 survivors, 9 were seriously injured and 1 slightly injured. Four of the survivors had first-degree burns resulting from contact with the jet fuel spread over the water on impact.

1.13.2 Fatalities

The 146 bodies recovered were all examined and autopsied at the University

Hospital Medical Center at Treichville in Abidjan. Forty-three of them could not be identified.

The condition of one body made it impossible to determine the nature of the injuries sustained. The injuries noted on the other 145 bodies were as follows:

- either serious poly-traumatic lesions: 108 persons,
- or only drowning lesions: 15 persons,
- or a combination of poly-traumatic and drowning lesions: 22 persons.

The autopsy report indicates that these traumatic injuries are related to a violent deceleration or to a twisting or cutting action.

In addition, 43 possessed first-degree burns through contact with the jet fuel spread over the water on impact.

The autopsy also revealed that the two pilots died from poly-traumatic lesions and had first-degree burns through contact with jet fuel.

Finally, toxicological examinations of the Captain and copilot revealed no traces of alcohol.

1.13.3 Identification

Of the 146 bodies recovered, 103 were identified.

1.14 Fire

There was no fire either before or after the impact.

1.15 Survival aspects

Abidjan Airport has an emergency plan that includes an alert procedure and a plan for deployment of the material and means defined therein.

1.15.1 Chronology and execution of rescue operations

The search and rescue operations phase is described hereafter:

30 January 2000

21 h 07 min 45 s: Last ground communication between the crew of flight KQ 431 and the control tower.

21 h 08 min 50 s: Take-off of flight KQ 431.

21 h 09 min 24 s: Accident

21 h 10: The controller called security and activated the alarm siren.

21 h 11: Alert issued to the Air Force, the search and rescue services responsible for aircraft in distress, the runway duty office and the Gendarmerie brigade.

21 h 15: Departure of airport firemen to the beach.

21 h 20: Arrival of the airport firemen in the site area.

21 h 30: The ASECNA head of ATC telephoned the GSPM, SAMU and 43rd BIMA. The Gendarmerie, the Police and an Air Force detachment arrived at the Ocean. The 43rd BIMA asked for permission to launch the COIA helicopter.

Between 21 h 30 and 22 h 00: a crisis center was set up at the ASECNA technical center, equipment was installed and a security zone established, information exchanged between the crisis center and personnel on the beach. A marine crisis center was set up at the Navy base at Locodjoro to coordinate the maritime searches. The port pilot boat put to sea with a team of firemen.

22 h 00: Two boats from the Ires, San-Pedro and the Iroko, based at the harbormaster's office, prepared to put to sea with firemen and paramedics from the SAMU. Boats from the GERSMA and other boats at the ASNA pontoon also prepared to put to sea.

Take-off of the Bonanza TU-VBH (Bouaké Air Base), on a mission to Abidjan, which searched for the accident site for 30 minutes without locating it.

- 22 h 14: Take-off of the Air Continental C206 (TU-TOA) to carry out a search.
- 22 h 30: COIA authorized the 43rd BIMA to launch the helicopter.
- 22 h 37: Take-off of the French Air Force Fennec (F-RAVB) to assist in the search.
- 22 h 44: Navy coastal ship the Amougan put to sea.
- 22 h 45: Take-off of Ivoire Hélicoptère helicopter (TU-THM).
- 23 h 10: San-Pedro put to sea with firemen and paramedics on board.
- 23 h 20: Ambulances from the SAMU, the airport medical service and the GSPM are transferred to the Socopao quay.
- 23 h 30: The tug Iroko passed through the channel, followed by the supply vessel Arbatan and the French tuna boat the Via avenir.
- 23 h 45: The Iroko, Artaban, San Pedro, Via Avenir and some pleasure boats arrived in the area of the extended runway centerline, still with no indication of the probable site of the accident. Operations were directed by the Chief Pilot of the Port of Abidjan. Each ship then had to cover an area by turning in wide circles.

31 January 2000

- 00 h 00: One of the pleasure boats signaled a strong odor of kerosene in the east of the extended runway center line area. The ships then maneuvered in that direction.
- 00 h 10: A pleasure boat signaled that it had found large quantities of floating debris and then almost immediately heard shouts.

- 00 h 20: The first survivor was recovered by the pleasure boat NRJ, which transferred him to the tug San Pedro. In 15 minutes, Wor'O2 recovered three more survivors who were also transferred to the San Pedro. These survivors were treated on the tug by SAMU doctors while awaiting evacuation to the Socopao quay, then to hospital.
- 00 h 30: F-RAVB (Fennec) returned to the 43rd BIMA, then took off again to continue the search.
- 00 h 35: The airport firemen discovered a survivor on the beach in the Adjouffou quarter and transferred him to the airport medical center in an ASECNA vehicle. He was then transferred to the Sainte Anne-Marie medical clinic in Abidjan.
- 02 h 00: The San Pedro, with four survivors on board, returned to Abidjan to deliver them to the Socopao quay.
- 02 h 15: Accident site discovered by the 43rd BIMA helicopter and search operation suspended due to bad weather.
- 02 h 30: 43rd BIMA ordered two inflatables from the CAML located on the lagoon side (about 30 kilometers away) to set off for the accident site.
- 03 h 16: The ASECNA firemen returned to the airport from the beach.
- 03 h 25: The Star Light II arrived at the Socopao quay with one survivor and five bodies on board.
- 03 h 30: Arrival of the two 43rd BIMA inflatables at the site.
- 03 h 48: Arrival of the San Pedro tug at the Socopao quay, with four survivors on board.
- 04 h 00: The Trojan arrived at the site of the accident. The Starlight II put to sea again. The ambulances set off to transport the injured to the Sainte Anne-Marie medical clinic.
- 06 h 50: Aerial search re-activated with the take-off of TU-THM and then F-RAVB helicopters.
- 10 h 00: End of the rescue operations. Return of the majority of the ships to the Socopao quay.

12 h 00: An analysis of the situation showed 10 survivors, all transferred to the Sainte Anne-Marie medical clinic in Abidjan, some of whom were in a serious condition, and 86 bodies recovered.

15 h 00: The medical teams left the Socopao quay.

Operations to recover bodies continued until 2 March 2000. At that time there were 10 survivors, 146 bodies recovered and 23 missing.

A Kenyan diver drowned on 5 February 2000 during operations to recover bodies.

1.15.2 Men and equipment mobilized

The following means were mobilized:

1.15.2.1 Men

14 doctors, including 10 specialists in reanimation/anesthesia and SAMU emergency doctors, 3 doctors from the airport medical center, as well as nurses, ambulance drivers, divers from the GERSMA and the GSPM, firemen from the ASECNA and the GSPM, Red Cross volunteers, troops from the Navy, the National Gendarmerie and the Air Force.

Security in the accident area was ensured by the Ivory Coast Navy during the search and rescue phase of the operations, from 30 January 2000 to 2 March 2000, during the mapping operations from 21 to 24 March 2001 and then during the underwater wreckage phase from 12 to 16 April 2001. From the time of the accident to the official closing of the investigation, the surveillance and protection of the site was ensured by the Port of Abidjan.

1.15.2.2 Equipment mobilized

- Several boats (IROKO, SAN-PEDRO, ARTABAN, AMOUGNAN, BSL ATCHAN, NRJ, WOR, STAR LIGHT I, STAR LIGHT II, TROJEAN, VIA AVENIR, KOO and BLOKOU) and some canoes,
- 5 inflatable boats (1 from the GSPM and 2 from the Navy),
- 1 trawler,
- 4 patrol boats,
- 1 Red Cross vehicle,
- 2 airplanes (TU-VBH and TU-TOA),
- 2 helicopters (F-RAVB and TU-THM),
- 2 VIMP,

- 1 VIPP,
- 1 “Follow me” vehicle,
- 1 lighting unit,
- 8 ambulances.

1.15.2.3 Means of communication between the ATC services and the ships

There were communication problems between the ATC services and the ships, since each activity is carried out on different frequencies.

1.15.3 Conditions

The search and rescue operations were made very difficult by the dark, the meteorological conditions and the site of the accident.

In fact, the night was very dark, and the aerial search was suspended due to fog. Taking into account the site of the accident and the absence of a quay near the runway, the operations had to make a long detour via the Vridi channel and then bring the survivors back to the Socopao quay.

1.15.4 Survival factors

The total destruction of the airplane on impact, the airplane's immersion and the sea conditions meant that there was little chance of surviving this accident.

The survivors were seated in seats 8H, 9G, 9F, 9B, in the forward cabin and seats 17A, 20G, 24B, 25A, 26A and 29B in the aft cabin.

A seating plan indicating the position of the survivors is included in appendix 11.

1.16 Tests and research

1.16.1 Examination of the fuel

Two samples of the fuel (JET A1) were taken from the main tank of the Shell refueling vehicle at Abidjan Airport immediately after the accident. Analyses of these samples were carried out by the Ivorian Refinery Company laboratory (SIR) in Abidjan and by the Abidjan SGS laboratory.

The results of these tests showed that the fuel was in conformity with the standards of the International Air Transport association (IATA).

None of the aircraft that had been refueled with the same fuel a short time before and after 5Y-BEN had any engine problems.

The results of the fuel analyses are included in appendix 10.

1.16.2 Spectral analysis of the CVR

A spectral analysis was performed in order to determine the engine speeds as well as the source of some of the recorded noises and alarms recorded on the CVR.

1.16.2.1 Engine speed

Spectral analysis showed that the N1 speeds of the engines remained constant at around 97% from the power up until the end of the recording at the moment of impact.

The graphs generated by the spectral analysis are included in appendix 12.

1.16.2.2 Noises and audio warnings recorded

In order to determine the origin of the noise recorded during rotation of the accident airplane (at 21 h 08 min 55 s), the CVR of another A310 on take-off was read out. The same noise was recorded at the moment of rotation of this aircraft. It was generated by the nose gear decompressing.

Spectral analysis of the noise recorded at 21 h 09 min 20.9 s by the accident airplane's CVR was compared with that of a "Whoop Whoop Pull Up" GPWS warning. The noise corresponded to the first 50 ms of the beginning of this warning.

1.16.3 Examination of the FDR and cockpit function test

An examination of the FDR was performed by CTSB at Honeywell, the manufacturer, in order to determine the reason why it did not record the flight data. The XA8 electronic card was tested and found to be operative. The other electronic cards in the FDR were damaged and were inoperative.

Some tests were performed at Airbus so as to determine if a visual FDR failure warning appeared in the cockpit when the FDR received and recorded a series of 0's and 1's. The tests showed that, in this case, the warning signal lit up.

The report relating to the recorders, in particular the FDR, is in appendix 13.

1.16.4 Study of the underwater videos

Some videos of the wreckage were made after the accident during the operations to recover the victims. Dives performed during the observation phase that followed the cartography of the accident zone were filmed by the divers and a robot. These films were studied and made it possible to determine the position of some moving parts of the airplane, in particular:

- the landing gear shock absorber that was twisted and in extended position;
- the flap actuator screw jack in the 15° position;
- a slat guide rail broken on the side where it was connected to the wing;
- the elevator actuator screw jack in a 1.2° nose up trim position;
- the fan blades on one engine severely damaged ;
- the second engine observed in two parts;
- on the cockpit center console, spoiler levers in the armed position (raised and locked).

1.16.5 Performance calculations for A310-304 and simulations

1.16.5.1 Performance calculations

At the request of the investigators, Airbus carried out take-off performance calculations. The initial conditions for these calculations were those observed flight KQ 431, which were as follows:

- Outside temperature 26 °C;
- Flex temperature 60 °C (corresponding to an engine speed of 97% of N1, according to the performances used by the airline);
- Aircraft weight 127 tons;
- Take-off configuration with flaps 15°, slats 15°;
- Center of gravity 25%;
- Take-off on runway 21 (altitude 23 feet);
- Wind calm (250° / 3 kt);
- Engine start up performed by using the GO lever.

The results of the calculations are shown in the following table:

Hypothetical configuration	Beginning of power up	100 knot call-out	V1 call-out
Take-off stop Packs off	0 second 0 meter	24.4 seconds 546 meters	36.8 seconds 1,897 meters
Take-off stop Packs on	0 second 0 meter	26.9 seconds 556 meters	39.6 seconds 1,934 meters
Rolling take-off Packs off	0 second 0 meter	18.1 seconds 541 meters	30.5 seconds 1,887 meters
Rolling take-off Packs on	0 second 0 meter	18.4 seconds 549 meters	31.1 seconds 1,919 meters

The first line indicates the time passed, calculated in seconds, between the beginning of the power up and the speed call-outs (100 knots and V1) and the second line indicates the distance run in meters.

Note that the study of the CVR (cf. appendix 7) showed that 19 seconds had passed between the beginning of the power up and the 100-knot call-out by the crew, and 33 seconds between the beginning of the power up and the V1 call-out. For the simulation undertaken by the manufacturer, V1 speed was 150 knots.

1.16.5.2 Simulations

At the request of the investigators, Airbus carried out some simulations on the Iron Bird development simulator. The aim of these simulations was to consider various scenarios that could lead to a stall warning and to examine the airplane's profile in these conditions.

- **First scenario: a loss of lift due to an uncommanded extension of the spoilers after take-off**

It was not possible to simulate an extension of the spoilers.

- **Second scenario: displacement of the center of gravity towards the aft at the moment of rotation**

The simulation was performed with a center of gravity 35% aft (maximum possible on a simulator) at the time of aircraft rotation without any control column input. A stall warning sounded 15 seconds after the rotation. The maximum pitch attitude obtained is 55° nose up. The maximum altitude reached by the airplane was 1,500 feet.

1.17 Information on Organizations and Management

1.17.1 The administration of civil aviation in Kenya

The Kenyan Civil Aviation Authority has technical oversight over Kenya Airways, on behalf of the Ministry of Transport.

The Authority is responsible for developing the applicable regulations for all air operations in public transport, for setting specific application conditions, for issuing authorizations and the corresponding approvals and for inspecting their application.

It is also responsible for investigations into aviation accidents.

The civil aircraft register for 30 December 2000 shows 799 aircraft registered.

The Kenyan Civil Aviation Authority is responsible for oversight of aviation safety. It nominates specialists to perform in-flight inspections.

1.17.2 Kenya Airways

Kenya Airways Ltd

Address: P.O. Box 19002 Nairobi (Kenya)

Kenya Airways is a private company operating public transport and cargo aircraft. Set up in 1977, it is the largest of the three Kenyan airlines. Originally owned by the Kenyan government, it was privatized in 1996 with KLM, the Dutch airline, as its main partner.

At the time of the accident, Kenya Airways employed 2,100 people and its fleet comprised 10 aircraft, including four (4) A310's, four (4) B737-300's and two (2) B737-200's.

The airline's internal management structure gives responsibility for handling incidents and anomalies to a Flight Safety Officer. The results of this work are circulated within

the airline. However, there is no program of flight analysis as such using the on-board flight recorders (CVR, FDR) and flight documents.

According to a Memorandum of Agreement signed on 23 October 1998 between the aeronautical authorities of the Republic of Ivory Coast and the Republic of Kenya, Kenya Airways has undertaken, since 28 March 1999, scheduled air transport services between Kenya and the Ivory Coast.

Thus, Kenya Airways performs three flights a week between Nairobi and Abidjan, via Lagos, on Wednesdays, Fridays and Sundays.

1.18 Additional Information

1.18.1 Testimony

Several witness statements were gathered, just after the accident and throughout the investigation, from aviation professionals, people working at the airport that undertook operational tasks, survivors of the accident and others. The following points came out of this testimony:

1.18.1.1 Aviation operations

Kenya Airways has a GSA with KLM. In this context, KLM supervises operations at Abidjan Airport.

Kenya Airways has a station assistance contract with Air Afrique. Thus, Air Afrique undertakes all assistance operations at the station. The agents who handled the flight on arrival noted nothing abnormal before the airplane took off.

1.18.1.2 Technical operations

Air Afrique's runway mechanics stated that the airplane was under the authority of a Kenya Airways mechanic. Air Afrique's mechanics only intervene if required. On that day, this was not the case, since the Kenya Airways mechanic did not notify any failures on the airplane.

The systematic operations on this flight were, arrival guidance, arrival headset operations and departure headset operations.

1.18.1.3 Fuel

Kenya Airways has a contract with Shell, which regularly refuels its aircraft at Abidjan. Thus, 23,854 liters of jet fuel were loaded onto the airplane, between 19 h 40 and 20 h 00, in the presence of the Kenya Airways mechanic.

1.18.1.4 Loading

The Air Afrique personnel responsible for loading the airplane stated that they unloaded the baggage on arrival and, later, unloaded those of the 18 passengers on flight KQ 431 who, during the Abidjan stopover, were able to get a Ghana Airways flight bound for Accra, their final destination.

1.18.1.5 Air Traffic Control

The Air Traffic Controller on duty on the day of the accident went on duty at 19 h 42. He stated that at 20 h 55 the Kenya Airways crew asked for start-up and pushback. During taxi, several instructions were given to them as well as departure clearance including a left turn after take-off and setting code 5040 on the transponder. The crew read back all of the instructions and the clearance.

The controller stated that the climb seemed difficult to him since the airplane's wheels left the ground practically after the central taxiway, unlike other Airbuses of the same type that generally take off before that taxiway. The airplane seemed to stabilize for a few seconds then began to lose altitude, then he lost sight of it.

He stated that there were no conversations between him and the crew after take-off at 21 h 09. One minute after take-off, that is to say at 21 h 09, the airplane crashed. He said that he set off the emergency alarm immediately, as required by the official procedures.

1.18.1.6 Alarm and rescue

The RFFS agents from the ASECNA mentioned a call from the Control tower on the on the safety frequency and the setting off of the emergency siren.

The owner of a restaurant located about two kilometers from the airport said that he immediately went by car to the 43rd BIMA police station, which is about a kilometer from his establishment, to raise the alarm. In his presence, the station head apparently called his superiors to inform them.

The ASNA was also alerted by a witness at 21 h 45.

The airport firefighters stated that their operations are carried out within an eight-kilometer radius from their base and that in case of need they work in concert with other emergency forces that have more appropriate equipment available. They asked assistance from the Military Fire Service Group, the Navy and the 43rd BIMA, which intervenes in case of disasters, in the context of the Abidjan Airport emergency plan.

The Abidjan Airport firefighters went to the seashore, on the extended runway centerline. When there, they obtained information from various local inhabitants to try to locate the accident site, but the various witnesses gave varying accounts of the site. They set up a lighting system on the beach, which allowed the others to establish an advance emergency rescue post.

At the request of the locals, some of those present went to work at the Jean Folly beach, located about 1.5 kilometers from the airport, where a survivor was taken into care, then to the airport health center at about 01 h 00 on 31 January 2000. They returned to base at about three in the morning.

1.18.1.7 The accident survivors

The survivors stated that, for the take-off, they heard an announcement to fasten their seatbelts for an imminent departure. The cabin crew performed checks to ensure that the passengers' seatbelts were fastened. The airplane took off normally, and no abnormal noise was heard on take-off.

A survivor said that he noticed that the airplane did not gain altitude as usual but rather lost height. An airport baggage handler said that the take-off did not seem normal to him and that he saw the airplane flying very low. It seemed to him that the airplane then disappeared rapidly from sight behind a bank of fog.

Several survivors stated that a short time after take-off the airplane started to descend rapidly. The airplane seemed to them to have swung suddenly to the left, then to the right, then to crash into the ocean with a deafening noise.

The survivors noticed that electrical power in the aircraft was shut off, though they were unable to say when this happened exactly.

They stated that there was no announcement from the crew before the accident.

Those who survived the accident said that they hung on to various floating objects.

Some said that some time after the accident they saw lights from helicopters pass over them without apparently seeing them. They added that they were later pulled out of the water by boats.

Some testimony is included in appendix 14.

1.18.2 Abidjan Airport emergency plan

The Abidjan Airport emergency plan specifies the organizations to contact and the rallying points and defines the organization of a rescue plan and the various groups responsible for operations, such as the fire service, the medical services, the police and the military authorities. Private or associative organizations can be called on to participate in the rescue efforts. People and equipment available are listed, along with their telephone numbers.

General exercise and coordination drills are planned every two years, which simulate the launch of the plan, the mobilization of rescue services and setting up of Command Centers up until the initial transportation of victims. Other drills take place in the years between the main ones that test a part of the overall groups and equipment or phases in the plan (alarm procedures, etc.)

1.18.3 Procedures recommended by the airline

To operate its aircraft, Kenya Airways uses an Operations Manual, an FCOM, a QRH, as well as a MEL specific to the airline, derived from the manufacturer's MMEL.

1.18.3.1 Procedures from the FCOM

The procedures described hereafter are taken from the second volume of the FCOM "**procedures and performances**", used by the airline. Thus, referring to:

- **Chapter 2.02.01: "procedures and techniques", "general", "recommendations for take-off and landing", "decision to reject the take-off above V1 »**, it is stated that the take-off must be continued since would be impossible to stop the aircraft on the length of the runway remaining and that no action may be taken (except cancellation of an audio warning) until:
 - the appropriate flight path is stabilized;
 - normal procedures are applied;
 - a height of at least 400 feet has been reached, in case of a failure during take-off, approach or go-around:

- a height of 400 feet is recommended because it is a good compromise between the time for flight path stabilization and the initiation of the procedure without excessive delay,
- in some emergency conditions, provided the appropriate flight path is established, the pilot flying (PF) may initiate actions before reaching the 400 feet AGL.

Kenya Airways stated that in accordance with its Standard Operating Procedures Amplified (SOPA), the height decided on for this operation was 1,000 feet.

In the same Chapter, in the "engine parameters monitoring" paragraph, it is stated that in addition to power adjustments by the pilot not flying (PNF) during take-off and landing phases, special attention must be paid by the PNF as regards surveillance of the engine parameters (N1/EPR, N2, EGT), especially during the take-off and go-around phases.

- **Chapter 02.02.09: "procedures and techniques", "flight controls", "recovery from stall warning (stick shaker)"**, it is stated that:
 - whenever a stall warning is encountered at low altitude (stick shaker activation), this must be considered as an immediate threat to maintaining a safe flight path;
 - the indications of a stall warning are the activation of the stick shaker and the speed symbol in the red and black strip on the PFD speed scale;
 - at the first indication of an imminent stall or on activation of the stick shaker, the following actions must be performed simultaneously: thrust levers in TOGA position, reduction of pitch attitude, wings level, check that speed brakes are retracted and slats extended (if below 20,000 feet and in clean configuration);
 - if there is any risk of collision with the ground, the pitch attitude must not be reduced any more than necessary in order to allow the air speed to increase;
 - after the initial recovery, maintain the speed close to the stick shaker speed until it is safe to accelerate (closely monitor the speed and the speed trend arrow);

- when the airplane is no longer stalling and if there is no danger of ground contact, the landing gear must be retracted, establish normal speed and select flap position as required;
- if an engine fails, power and the rudder must be used with care.
- **Chapter 02.03.12: "standard operating procedures", "take off"**, the take-off procedure is described. The following procedural elements are of note, in chronological order:
 - when rotation speed is reached, the PF performs a smooth rotation and continues in order to reach the pitch attitude required (which must not exceed 18 degrees) as indicated on the SRS pitch control bar;
 - the pitch attitude bar allows $V_2 + 10$ knots to be maintained or a maximum pitch attitude of degrees;
 - if the SRS is not available, perform the rotation up to a pitch attitude of 12.5 degrees;

The "positive climb" call-out is made when the vertical speed indicator is positive, then the « gear up » order is given and then the landing gear lever is moved to the "up" position (landing gear retracted);

 - the speed brakes are disarmed;
 - the nose and runway illumination lights are off (they can remain on if the operator so wishes);
 - the autopilot can be engaged. If it is already active in CWS mode, this can be changed to CMD mode.
- **Chapter 02.04.10: "emergency procedures", "introduction", "task sharing"**, it is stated that in case of a master warning, PF and PNF task-sharing is to be as follows:
 - the PF remains PF throughout the procedure;
 - however, when actions can only be performed from one side (e.g. landing gear gravity extension) tasks must be distributed accordingly;

- the PF is responsible for the throttle levers, flight path and airspeed control, aircraft configuration, navigation and communications (PF orders and PNF executes),
 - the PNF is responsible for reading the ECAM and QRH, execution of ECAM actions and paper check-list(s), upon PF command, and actions on fuel levers, fire handles and guarded switches (with PF confirmation).
- **Chapter 02.04.10: "emergency procedures", "introduction", "ECAM"**, it is stated that all warnings are inhibited at the ECAM on take-off as long as the speed is over 70 knots and the height is lower than 400 feet, except for the ENGINE FIRE, ENGINE FAIL, APU FIRE warnings and that the take-off configuration warning is inhibited after the aircraft has left the ground.
 - **Chapter 02.04.34: "emergency procedures", "GPWS alerts"**, the procedure to follow when a "whoop whoop pull up" warning occurs is:
 - simultaneously :
 - select a nose up attitude of at least 20 degrees (the stick shaker activation limit is used as the maximum limit for pitch attitude),
 - thrust levers at full,
 - disconnect auto-throttle,
 - disconnect autopilot,
 - keep wings level,
 - check that the speed brake lever is in the retracted position;
 - when the flight path is safely established and the GPWS warning stops, reduce the pitch attitude and accelerate;
 - when the speed is above VLS and the vertical speed is positive, configure the aircraft as required.

Chapters 2.02.09 and 2.04.10 of the FCOM are included in appendix 15.

1.18.3.2 Procedures from the QRH

The procedures described hereafter are from the QRH used by the airline's crews.

- **Chapter 6.04: "flight control", "inadvertent stick shaker"**, the procedure to follow when unusual stick shaker activation occurs is as follows:
 - pull the circuit breaker on the side corresponding to the side affected by the shaking on the column (Captain or copilot side).
- **Chapter 13.01: "miscellaneous", "unreliable airspeed"**, it is stated that in case of an erroneous airspeed indication, if the audio stall warning and stick shaker are activated, the stall recovery procedure must be applied. It is indicated that in this case the audio stall warning and stick shaker use information based on the angle of attack and must be followed.

1.18.4 Function of the take-off configuration warning

The take-off configuration warning is activated as soon as one of the engines reaches take-off thrust, until the aircraft leaves the ground. The criteria for activation of the warning and the warning's operation are described hereafter:

- if the flaps are not at 0° or 15° or 20°, the "master warning" lights up, the problem is displayed on the Warning Display (WD), and a Continuous Repetitive Chime (CRC) is set off;
- if the slats are not at 15° or 20°, the "master warning" lights up, the problem is displayed on the Warning Display (WD), and a Continuous Repetitive Chime (CRC) is set off;
- if the value of the elevator trim is not between 2.3° nose up and 3.5° nose down, the "master warning" lights up, the problem is displayed on the Warning Display (WD) and the System Display (SD), and a Continuous Repetitive Chime (CRC) is set off;
- if at least one of the outer speed brakes is not retracted, the "master warning" lights up, the problem is displayed on the Warning Display (WD) and the System Display (SD), and a Continuous Repetitive Chime (CRC) is set off;
- if the parking brake is not released, the "master warning" lights up, the problem is displayed on the Warning Display (WD) and a Continuous Repetitive Chime (CRC) is set off; in the case of the parking brake, the configuration warning is no longer active between 70 knots and take-off.

1.18.5 Slats and flaps control system and alpha lock protection

The same lever controls the slats and the flaps. It allows selection of five slat/flap positions: 0°/0°, 15°/0°, 15°/15°, 20°/20° and 30°/40°.

Where the 0°/0° position is selected while the angle of attack is above 9° and the speed is above 60 knots, the alpha lock is automatically activated: it limits the slat retraction to 15° and prevents the Kruger flaps and angled ailerons from retracting. As soon as the angle of attack is below 9°, the alpha lock protection is de-activated: the slats, the Kruger flaps and the ailerons retract. Activation of this protection is displayed on the SFPI (Slat/Flap Position Indicator) by illumination of the blue "alpha-lock" light.

1.18.6 Warnings and automatic announcements in the cockpit

The order of warnings in the cockpit, when the airplane is in flight, from the highest to the lowest priority is as follows:

- stall warning;
- overspeed warning;
- GPWS warnings.

If the criteria for activation are met at the same time, the highest priority warning is activated and the other one does not appear in the cockpit.

A CRC (Continuous Repetitive Chime) is associated with a master warning and can be generated (after take-off at a height below 400 feet with the gear extended) by:

- an engine fire;
- an Auxiliary Power Unit fire (APU);
- an overspeed (VMO/MMO, VFE, VLE);
- a loss of oil pressure on an engine with a value under 11 PSI \pm 1.5.

The automatic height callout system is only active when the airplane is descending, whatever its configuration may be, from 4000 feet and below.

1.18.7 Stall warning system

The stall warning system is made up of two angle of attack sensors located on either side of the forward part of the fuselage, two Air Data Computers (ADC) and two Flight Warning Computers (FWC) that initiate the stick shaker and the audio warning in case of approach to stall. It is enough for one of the angle of attack sensors sends an appropriate value or for the computed stall speed to be close for the warning to be activated. The criteria for the warning to be activated are as follows:

- if the slats are at a position lower than 15° (retracted or moving from 15° towards zero) and the angle of attack is greater than 10°, or
- if the slats are extended to 15° or more and the angle of attack is greater than 17.5°,
- if the V_{ss} (stick shaker activation speed) is less than 1.138 V_s (computed stall speed) in smooth configuration,
- if the V_{ss} is less than 1.08 V_s in non-smooth configuration.

The stick shakers are activated on the Captain and copilot sides as soon as the warning is active. When the conditions for warning activation are met, they can only be de-activated by pulling the associated circuit breaker.

The audio warning is generated by the same signal as the stick shakers. It is generated about ten seconds after stick shaker activation. It can be cancelled by pushing the audio warning cancellation button. This action cancels the audio warning but not the stick shakers nor the indications in the cockpit associated with the stall warning.

1.18.8 Study of the CRC heard at 21 h 09 min 22.5 s

A Continuous Repetitive Chime (CRC) is associated with a master warning and can be generated (after take-off at a height of less than 400 feet with gear extended) by:

- an engine fire;
- an Auxiliary Power Unit fire (APU);
- an overspeed (VMO/MMO, VFE, VLE);
- a loss of oil pressure on an engine with a value under 11 PSI \pm 1.5.

The hypothesis of a CRC caused by an engine fire, an APU fire or a loss of oil pressure on an engine with a value under $11 \text{ PSI} \pm 1.5$. was judged to be unlikely by the Commission. The crew does not, in fact, mention a fire problem or an engine problem. In addition, the engine speeds recorded on the CVR remain constant, from the beginning of the power until the impact.

Furthermore, the simulations carried out at Airbus showed that at the time of the impact, the airplane's speed was greater than 210 knots (VFE: configuration with flaps/slats extended $15^\circ/15^\circ$).

The Commission of Inquiry estimated that it was very unlikely that the warning heard at 21 h 09 min 22,5 s was an overspeed warning.

1.18.9 Training of A310 crews at the airline

1.18.9.1 Training

The pilots follow an A310 training course within Kenya Airways. This training is comprised of an A310 ground school followed by TTR (Technical Test Rating). The full flight simulator training is undertaken at Air France or with Emirates. The practical part is undertaken within the airline. The whole course is approved by Airbus and the Kenyan civil aviation authorities.

Training for the successive ratings (Copilot and Captain) are undertaken according to seniority and the airline's needs.

A Pilot Crew Resource Management Course (CRM) is given to all the airline's flight crews. During the training and scheduled tests, the crews are exposed to CRM problems.

Type ratings and recurrent training are approved and inspected by the Kenyan civil aviation authorities.

During type rating, crews are trained to react to a stall warning according to the procedure described hereafter, taken from the August 1989 Aeroformation Flight Crew Training Manual.

At the first indication of a stall or stick shaker activation warning:

- trust levers full forward;
- smoothly roll wings level;

- smoothly adjust the pitch so as to minimize loss of altitude and avoid ground contact;
- select slats 15°;
- as long as there is a risk of ground contact, reduce indicated airspeed to VSS, but never below;
- respect the stick shaker and do not take into account the FD bars;
- if possible, select FPV or de-activate FD.

In the summary of the procedure, attention is particularly drawn to the need to respect the minimum stick shaker speed to avoid ground contact with the following phrase: "Respect stick shaker – minimum speed to avoid ground contact VSS".

1.18.9.2 Recurrent training

In-flight checks and simulator

The airline applies type A and B in-flight check programs. The type A instrument rating and emergency procedures check is valid for 12 months, the type B emergency procedures check is also valid for 12 months. They are carried out with regular six month intervals between the two.

Notes:

- the A310-300 Flight Simulator Training published by the manufacturer and used by the airline does not contain any particular training related to stall warnings. However, this aspect is covered during type rating;
- during their careers in the airline, crews do not follow CRM backup courses. During training and planned checks, crews are exposed to CRM problems.

1.19 Useful or effective investigation techniques

Cartography and underwater observation of the wreckage was carried out between March and April 2001. This essential work required the use of considerable technical, maritime and human resources. It made it possible to draw up a very precise chart of the debris(position, size, shape). Bearing in mind the accretions and silt that built up on the wreckage, the observations made more than a year after the accident made it impossible to recognize the majority of the debris. Nevertheless, the aircraft's configuration at the time of the impact with the sea was able to be determined.

The equipment used for this work comprised two ships, some anchor lines, a shipboard DGPS and gyrocompass, a differential position GPS (Trimble AG 132), diving equipment, video equipment (NC-300 type) and a Remotely Operated Vehicle (ROV).

2 - ANALYSIS

2.1 Accident scenario

On 30 January 2000, the aircraft registered 5Y-BEN undertaking flight KQ 430 Nairobi-Lagos-Abidjan landed at Abidjan at 15 h 15. The unfavorable meteorological at Lagos had obliged the pilot, after a thirty minutes hold at Lagos, to divert to Abidjan.

In the evening, the airplane undertook flight KQ 431 from Abidjan to Nairobi via Lagos, with 10 crewmembers and 169 passengers on board as well as 7.841 kg of cargo and 25.51 tons of fuel. The airplane's takeoff weight was 127,855 kg.

The copilot was pilot flying (PF); the Captain was pilot not flying (PNF).

No events of any particular significance were noted before takeoff.

The crew prepared the aircraft for takeoff; the planned takeoff configuration was in accordance with the conditions on the day: slats 15°, flaps 15°, trim 0.9 nose up, takeoff with reduced thrust temperature set at 60 degrees (flex take-off 60), spoilers armed, automatic braking selected on maximum, V1=149 kt, VR=151 kt and V2=154 kt.

The airplane began taxiing and at 21 h 07 min 35 s the tower controller communicated the latest wind, (240°/04 kt), cleared them for takeoff and asked the crew to call back after passing flight level 040.

At 21 h 07 min 45 s, the copilot read back the clearance. That was the last communication between the crew and the control tower.

At 21 h 08 min 08 s, the pre-takeoff checklist was completed, and the copilot announced that they were cleared for takeoff.

At 21 h 08 min 18 s, the Captain applied takeoff power (97% of N1). The maximum available engine thrust corresponds to 117.5% of N1. The auto-throttle was engaged in thrust mode (maintain thrust). In case of need, the crew can increase engine thrust by around 25% by selecting TOGA thrust (maximum thrust). They called out "thrust, SRS and runway", which means that the power was applied, that the SRS (Speed Reference System) was operating and that the guidance system allowing the aircraft to hold the runway centerline was activated. Nineteen seconds later they called out 100 knots then, thirteen seconds later, "V1 and Rotate). These callouts are in accordance with the aircraft's theoretical performances.

Thirty-eight seconds after thrust initiation, at 21 h 08 min 56, the airplane took off and the Captain announced "positive".

One second later, the copilot (PF) called out "Positive rate of climb, gear up", which indicates that the airplane was climbing. This callout was followed by the aural stall warning, probably preceded by the stick shaker activating. The PNF did not carry out the order to retract the gear. The copilot, pilot flying, pushed forward on the control column in reaction to the stall warnings. This action was probably maintained until the impact.

Several witnesses stated that the track the airplane followed after takeoff was lower than that of airplanes of the same type that they were used to seeing on take off. The airplane climbed to a height between 300 and 400 feet then began to descend. At 21 h 09 min 07 s, the copilot asked, "What's the problem?"

From 21 h 09 min 16 s, the radio altimeter called out, successively, 200, 100, 50, 40, 30, 20 and 10 feet.

Meanwhile, at 21 h 09 min 18 s, less than a second before passing through 100 feet in descent, the copilot ordered the aural stall warning alarm to be disconnected. The stall warning disconnect button was pushed and the aural stall warning alarm stopped at 21 h 09 min 20 s. The GPWS then immediately sounded a "Whooo", which was inaudible to the crew, this being the beginning of the "Whoop whoop pull up" ground proximity warning.

At 21 h 09 min 22 s, the CRC (Continuous Repetitive Chime) began, which corresponds to a master warning of over-speed with flaps extended, immediately followed by an order from the Captain "Go up!".

At the time this over-speed warning sounded, the airplane's speed was at least 210 knots, the maximum speed limit for a configuration with slats/flaps at 15°/15°. This speed is explained by the fact that the engines were still supplying takeoff thrust whilst the airplane was in descent.

At 21 h 09 min 23.9 s, the master warning stopped, followed immediately within a tenth of a second by the sound of the impact.

2.2 Possible scenarios leading to stall warning initiation

Various scenarios that could lead to a stall warning were studied.

A stall warning associated with a true stall situation can be caused by a speed close to a stall speed or a high angle of attack. Various events may cause these two parameters to evolve:

- incorrect configuration of the airplane on takeoff;
- erroneous speed indication in the cockpit;
- loss of engine power;
- uncommanded retraction of the slats;
- sudden displacement of the center of gravity towards the aft due to cargo moving in the hold;
- uncommanded deployment of the thrust reversers;
- uncommanded deployment of the spoilers.

A stall warning that does not correspond to a true stall situation (false alarm) can be caused by:

- an FWC anomaly leading to activation of the aural warning without the stick shaker;
- an FWC anomaly leading to activation of the aural warning with the stick shaker;
- a damaged angle of attack sensor giving erroneous angle of attack information to the FWC;
- an erroneous speed calculation.

2.2.1 Study of scenarios corresponding to a stall situation

The Commission of Inquiry examined scenarios corresponding to a true stall situation.

2.2.1.1 Airplane configuration on takeoff

The selected flap/slat position announced by the crew before takeoff was 15°/15°.

If the flaps or slats had been retracted during the takeoff roll, the configuration warning alarm would have been set off. As no alarm is recorded on the CVR during this phase, this indicates that the aircraft took off with the flaps and slats in the 15°/15° position.

Further, observations on the wreckage showed that the position of one of the flaps was: extended to 15°. The slats/flaps control lever has only one position allowing a position with flaps extended to 15°: slats 15°/flaps 15°. Consequently, after the accident, the position of the flaps and slats was flaps: 15°/slats: 15°.

The airplane configuration on takeoff was normal, flaps 15° and slats 15°.

In conclusion, the stall warning was not initiated by an incorrect airplane configuration.

2.2.1.2 Speed indication in cockpit

Performance calculations made by the manufacturer show that the time recorded on the CVR between the beginning of the power up, the 100-knot callout and the V1 callout correspond to a rolling takeoff with packs ON.

The time coherence also shows that the real weight of the aircraft was close to that indicated on the weight and balance sheet, that is about 127.8 tons.

Finally, the speed callouts were performed at the time when these speeds should, by calculation, be displayed in the cockpit. This shows that the speeds were displayed correctly in the cockpit and rules out the hypothesis of an incorrect speed indication.

The speed indicated in the cockpit was correct.

In conclusion, the stall warning was not initiated by a speed close to the stall speed.

2.2.1.3 Takeoff thrust during the flight

The engines maintained takeoff thrust during the flight. In fact, spectral analysis showed that the engines' N1 remained constant at around 97%, from the power up until the end of the recording at the moment of impact. A change in the engine speed would have led to a change in the engine noise, which would have been heard on the CVR and been visible during the spectral analysis.

In conclusion, the stall warning was not due to a loss of thrust on the engines.

2.2.1.4 Uncommanded slat retraction

The selected flap/slat announced by the crew before takeoff was: 15°/15°.

If the slats or flaps had been retracted during the takeoff roll, the configuration warning would have sounded. Since no warning is recorded on the CVR during this phase, this indicates that the aircraft took off with the flaps and slats in the 15°/15° position.

Observations on the wreckage showed that the position of one of the flaps was: extended to 15°. The slats/flaps control lever has only one position allowing a position with flaps extended to 15°: slats 15°/flaps 15°. Consequently, after the accident, the position of the flaps and slats was flaps: 15°/slats: 15°.

The cause of the stall warning after the rotation was not the uncommanded retraction of the flaps/slats. In fact, if at the time of the beginning of the stall warning:

- the airplane's angle of attack was lower than 9°: if the flaps/slats retract, the stall warning is not activated (stall warning initiation criteria are: angle of attack greater than 10° slats retracted or 17.5° slats extended);
- the airplane's angle of attack is greater than 9°: the alpha-lock protection prevents the slats from retracting.

In conclusion, from power up to the impact, the airplane's configuration remained the same, that is to say: flaps extended at 15° and slats extended to 15°. The stall warning was not initiated by an uncommanded retraction of the slats.

2.2.1.5 Displacement of the center of gravity towards the aft

Simulations carried out on the development simulator by the manufacturer contradicted the hypothesis of a rapid displacement of the airplane's center of gravity towards the aft (caused, for example, by movement of one or more of the containers in the hold) at the time of the rotation. In fact, such an event would result in:

- initiation of the stall warning 15 seconds after rotation, whereas it was set off much earlier (immediately after the rotation);
- a maximum angle of attack of 50 degrees whereas witnesses indicated that the airplane did not have a noticeably nose-up attitude;
- passing through 400 feet in altitude, an altitude that the airplane never reached;
- scraping of the tailskid on the runway, which would have caused sparks to fly, visible at night. No scraping sound was heard on the CVR and no sparks were reported by the witnesses.

In conclusion, the stall warning was not initiated by an uncommanded displacement of the center of gravity towards the aft.

2.2.1.6 Uncommanded deployment of the thrust reversers

There was no deployment of the thrust reversers in flight since that would have resulted in a change in the engine noise that would have been heard on the CVR and observed on the spectral analysis.

In conclusion, the stall warning was not initiated by an uncommanded deployment of the thrust reversers.

2.2.1.7 Uncommanded deployment of the spoilers

Performance calculations made by the manufacturer show that the time recorded on the CVR between the beginning of the power up, the 100-knot callout and the V1 callout correspond to a rolling takeoff with packs ON. This implies that the spoilers were in retracted position until takeoff.

Further, no configuration warning resulting from a movement of the spoiler levers was heard on the CVR. There was thus no indication that the crew deliberately extended the spoilers during this phase of flight.

A study of the underwater video recordings made it possible to determine the position of some moving parts of the airplane, in particular the spoiler lever in the armed position (raised and locked) on the cockpit center console.

In fact, in this configuration, an uncommanded extension of the spoilers could only be possible and automatic under the following necessary conditions:

- rear main landing gear wheel rotation speed greater than 85 knots, and
- both thrust levers on idle, which was not the case since that would have resulted in a change in engine noise that would have been heard on the CVR and observed on the spectral analysis.

These two conditions must be combined with one of the following situations:

- selection of one of the two thrust reversers, which was not the case since that would have resulted in a change in engine noise which would have been heard on the CVR and observed on the spectral analysis, or
- compression of the landing gear shock absorbers, which was not the case, as confirmed by the position of the landing gear recovered from the sea.

In conclusion, the stall warning was not initiated by an uncommanded extension of the spoilers.

Finally, taking into account the various facts gathered by the investigation, the scenarios based on a true stall situation were excluded by the Commission.

2.2.2 Scenario selected

The architecture of the stall warning is organized so that the stick shaker and the audio warning are set off by the same signal from the FWC. Nothing suggests that the stick shaker was not activated, while the alarm was operative.

The most likely scenario is therefore that there was a false alarm, probably with activation of the stick shaker. The investigation was unable to determine precisely the cause of this false alarm being generated. It could be generated by an anomaly in the airplane's speed calculation system (for example, an ADC anomaly), in the airplane's angle of attack calculation system (for example, an anomaly in one of the angle of attack sensors) or in the stall warning generation system (for example, an FWC anomaly).

A list of cases of stall warning activation without a true stall situation having occurred is included in appendix 16.

2.3 Management of the warning

2.3.1 Task-sharing and management of a warning on takeoff

In the case of a decision speed warning, during take-off and initial climb, the pilot flying maintains the climb path and continues the flight. The PNF manages the warning as soon as it appears. It is recommended to wait until an adequate height with a stabilized path to begin applying the failure procedure to be carried out. During this time, only the cancellation of the audio warning can be effected.

2.3.2 The specific case of the stall warning

The occurrence of a true stall warning during the take-off and climb phase is extremely rare. In addition, the recovery procedures when approaching a stall taught during type rating do not take this phase of flight into account. They are described only for en route and approach phases.

The procedure described in the Airbus FCOM, validated by the Kenyan civil aviation authorities and used by Kenya Airways requires that the crew react immediately to stick shaker activation to ensure flight continuity. According to the logic of the warning system operation, the black and red strips symbolizing the stick shaker initiation speed should appear on the PFD speed scale. It is not displayed during the five seconds following take-off. Two immediate and simultaneous actions are recommended: maximum engine thrust (TOGA) and a reduction in the pitch attitude until initial recovery, that is to say until the stick shaker stops. This action should have an immediate effect on the stick shaker. The pitch attitude obtained as soon as the stick shaker stops must be maintained to allow the speed to increase while minimizing the loss of altitude.

The general case applied when handling a failure on take-off is not to be applied when dealing with a stall warning, where the flight path must immediately be modified and closely watched.

The QRH, like the FCOM, refers to untimely stick shaker activation. It is then recommended in case of a false alarm to pull the appropriate circuit breakers.

2.3.3 Crew's handling of the stall warning

2.3.3.1 The pilot flying (PF)

The airplane did not go above a height of 400 feet and began to descend a short time after the rotation while the engines were delivering take-off thrust, which shows that as soon as the stall warning appeared, the PF reacted by reducing the pitch angle. If, in fact, the airplane had got above 400 feet, the first callout heard would have been "400". However, the first height callout from the radio altimeter (300 feet) appears twelve seconds after take-off. This indicates that the plane was already descending. The regular callouts of falling height values from 300 feet to 10 feet shows that the airplane continued to descend, and thus that the PF maintained his action on the control column. In a take-off configuration, a slight nose down attitude is enough to cause the airplane to descend.

His immediate action on the control column was in accordance with the procedure specified by the airline. His insistence can be explained by the fact that he was expecting his action to stop the stall warning, which did not happen. In addition, the audio warning, the stick shaker and the vertical acceleration caused by the pitch change are symptoms of a stall and were thus likely to make the PF persist in his action.

Further, the PF did not apply TOGA thrust, whereas it should have been applied simultaneously with his action on the control column. The procedure was thus only partially applied. The PF should also have had various sources of information at his disposal (speed, speed trend bar, engine thrust, etc.) that should have made him aware that it was a false alarm. It should, however, be noted that when the master warning was initiated, information on the VSS (red and black strips) was not immediately available on the crew's PFD, this being part of the design of the computer. This symbol is only displayed on the PFD five seconds after the takeoff.

Finally, he does not appear to have been aware that his flight path was heading towards the ground. It should be noted that the GPWS was never heard by the pilots. Only a 50 millisecond "whoop", inaudible to the crew, was identified during the CVR analysis. The architecture of the airplane in fact creates a hierarchy in the priority given to warnings and their associated alarms. The GPWS warning was masked by the stall and overspeed warnings.

Various disturbing events may have contributed to his not applying the stall recovery procedure completely, to his failing to determine that it was a false alarm and to his lack of awareness of his vertical position. These events include the fact that: this type of warning is unexpected during this phase of flight; the stick shaker and the audio warning used up a lot of his resources (he asked the PNF to cancel the audio warning 19 seconds later); the take-off towards the sea on a pitch-black night did not give him any visual indications on the airplane's attitude, in particular on its height, and the stick shaker continued to act despite his actions.

2.3.3.2 The pilot not flying (PNF)

During the runway acceleration phase the PNF, on that day the Captain, made the expected callouts: "thrust, SRS and runway", then "take off power set", "one hundred knots", "V1 and rotate". Immediately on takeoff, he called out "positive".

Following this callout, the PF answered: "positive rate of climb, gear up". At that moment, the warning sounded, the PNF said (uhooo), which showed his surprise, and did not retract the gear. The CVR transcript shows that 19 seconds later the PF asked for the audio warning to be turned off and that the PNF pushed the "EMER AUDIO CANCEL" button. No other action by the PNF was determined until 21 h 09 min 23 s when he ordered "go up", while the radio altimeter had just called out 10 feet and the "over speed (VFE)" CRC was set off. This "go up" order by the PNF shows that he was becoming aware of the proximity of the ground, though only one second before the impact. The radio altimeter "300", "200", "100" callouts could have led the Captain to give this order earlier. He does not appear to have heard them.

This late awareness can be explained by the unusual nature of the warning and the stress that it can provoke. The outside environment (no spatial or ground references and the pitch-black night) was a hindrance to the Captain's appreciation of the airplane's attitude.

It was not possible to establish if the PNF deliberately interrupted the landing gear retraction sequence or if he was disturbed by the warning. The FCOM states that in the case of an approach to stall with the gear extended, it must only be retracted when the airplane is no longer in a stall situation and there is no longer any risk of ground contact.

2.3.3.3 Crew coordination

The stall warning, inhibited while the airplane is on the ground, was initiated just after the airplane took off. The PF reacted rapidly by pushing the control column forward, which interrupted the initial climb the put the airplane into a descent. The time given the crew to deal with the warning before hitting the sea was less than 30 seconds.

From the time the warning sounded, there was no dialogue between the pilots. The only verbal exchange concerned the request to stop the audio warning, which we know was done. The Captain's "go up" order is heard on the CVR one second before the impact. It is the only message relating to flight path management.

2.4 Flight Crew

The flight crew of flight KQ 431 from Abidjan to Nairobi via Lagos on 30 January 2000, consisted of a Captain and a Copilot.

The flight crew possessed the ratings and licenses required by the Kenyan regulations and were in accordance with ICAO standards for the posts they held and the route they were flying. All of their ratings and licenses were valid at the time of the accident.

The number and make-up of the crew was in accordance with the Kenyan civil aviation and Kenya airways regulations for the A310 airplane and the Abidjan-Lagos-Nairobi route they were flying.

Equally, the positions the flight crewmembers occupied and the tasks they were carrying out were in accordance with the applicable rules laid down by the relevant Kenyan civil aviation authorities.

In Abidjan they had had a rest period that was in accordance with the regulations before taking up their posts to undertake flight KQ 431 on 30 January 2000.

As regards the crewmembers' training and experience, it should be noted that:

The Captain (aged 44)

He joined Kenya Airways on 30 April 1984, from Pioneer Airlines, and had obtained his professional pilot's license on 10 August 1988 in Nairobi and had worked as Captain on F27, F50, B737-200, B737-300 and A310. He had undertaken his A310 Captain's training course at Airbus Training in Toulouse on 20 July 1999. Before the day of the accident he had a total of 11,636 20 minutes flying hours, of which 1,664 hours in total on A310 and 570 hours 35 minutes as Captain on A310. He had fulfilled the regulatory requirements with a line check on 20 July 1999 and a base check on 31 October 1999. Since 15 August 1999 he had performed four landings and four take-offs from Abidjan Airport.

The Copilot (aged 43)

He joined Kenya Airways on 1st July 1988 and had obtained his professional pilot's license on 4 August 1999 in Nairobi and flown as copilot on DC9 and A310. He obtained the A310 type rating in March 1991. Before the day of the accident, he had a total of 7,295 hours and 32 minutes flying hours, of which 5,768 hours 47 minutes as copilot on A310. He had fulfilled the regulatory requirements with a line check on 29 July 1999 and a base check on 10 October 1999. Since 6 August 1999 he had performed four landings and four take-offs from Abidjan Airport.

To summarize, according to the evidence gathered by the investigation on the training and experience of the members of the flight crew, The Commission of Inquiry was of the opinion that they were technically qualified and had good experience of flying jet aircraft and the A310 and that they had the necessary training and experience to carry out their tasks safely.

2.5 Aircraft

The airplane registered 5Y-BEN possessed a Certificate of Airworthiness issued by the appropriate Kenyan civil aviation authorities in accordance with the type certificate n°13896, valid until 21 December 2000.

The airplane was maintained in accordance with the Kenya Airways A310 Maintenance Manual approved by the Kenyan civil aviation authorities. The last type A check had been carried out on 27 January 2000, three days before the accident.

All of the Airworthiness Directives applicable on the date of the accident had been applied, with the exception of AD2000-007-301 (B) concerning the loss of auto-trim function. This directive relates to a trim problem with autopilot engaged. During the accident, the autopilot was not engaged. Consequently, the non-application of this AD cannot be linked to the accident.

The Commission was not able to examine the Technical Log of flight KQ 430 on arrival at Abidjan or that of flight KQ 431 on departure from Abidjan and was thus unable to pronounce on the technical situation of flight KQ 431 on 30 January 2000 on departure from Abidjan. The logbook containing the copies of the Technical Log was on board flight KQ 431 and was not found after the accident. A copy of the Technical Logs should have been left at Abidjan before take-off. The investigation was unable to find this copy.

None of the evidence presented could lead the Commission of Inquiry to conclude that the technical situation of the airplane could have affected the safety of the flight. In fact, no such indications were heard on the CVR. In addition, the testimony by the Air Afrique ramp mechanics indicated that the Kenya Airways accompanying mechanic did not ask Air Afrique for any technical assistance with the airplane during the Abidjan stopover or before the departure of flight KQ 431.

The airplane had a takeoff weight of 127,855 kg, for a maximum takeoff weight of 153,000 kg and a center of gravity at 26.27% of the Mean aerodynamic Cord for an allowed balance range at this takeoff weight from 20.6% to 34.5%.

The loading and the center of gravity were in accordance with Kenya Airways procedures and within the allowed limits at the time of the accident.

The CVR recorded the noises in the cockpit, in particular the audio warnings associated with a stall and overspeed, up until the impact. The airplane's independent electrical system that allows, among other things, the generation of these warnings and operation of the CVR, thus suffered no malfunction before the impact.

The tests performed on the FDR showed that the malfunction it had suffered should probably have activated a warning light in the cockpit. According to the MEL applied by the airline, as long as the CVR was operative, the airplane could perform flights from airports where there were no facilities available to replace the FDR. However, on departure from Nairobi where there are appropriate facilities, the aircraft is not authorized to take off before the FDR is replaced or repaired. It is possible that the warning lights indicating the failure were defective. In that case, the defective lights should have been detected by the crew during the pre-flight checks each time the plane departed. Since this malfunction had existed for at least the last 25 flying hours, it was present before the last departure from Nairobi of flight KQ 430.

The Commission of Inquiry concluded that this malfunction existed before the last departure from Nairobi of flight KQ 430 but that the inoperative condition of the FDR had no connection with the accident.

3 - CONCLUSIONS

3.1 Findings

The members of the flight crew of flight KQ 431 on 30 January 2000 possessed the ratings and licenses required by the Kenyan regulations and were in accordance with ICAO standards for the posts they held and the route they were flying. All of their ratings and licenses were valid at the time of the time of the accident.

The number and make-up of the crew was in accordance with the Kenyan civil aviation and Kenya airways regulations for the A310 airplane and the Abidjan-Lagos-Nairobi route they were flying.

Equally, the positions the flight crewmembers occupied and the tasks they were carrying out were in accordance with the applicable rules laid down by the relevant Kenyan civil aviation authorities.

In Abidjan they had had a rest period that was in accordance with the regulations before taking up their posts to undertake flight KQ 431 on 30 January 2000.

The airplane registered 5Y-BEN undertaking flight KQ 431 on 30 January 2000 possessed a valid Certificate of Airworthiness. The airplane was maintained in accordance with the Kenya Airways A310 Maintenance Manual approved by the Kenyan civil aviation authorities.

The airplane's configuration was normal for the takeoff: landing gear extended and locked down, flaps and slats extended to 15 degrees.

The loading and the center of gravity were in accordance with Kenya Airways procedures and within the allowed limits at the time of takeoff and at the time of the accident.

The engines were delivering thrust corresponding to a takeoff with thrust reduced to 97% of N1, in accordance with the airplane's weight and the conditions on the day. They continued to deliver this thrust until the moment of impact.

A stall warning activated as soon as the aircraft left the ground.

As soon as the warning activated, the post-takeoff checklist was stopped.

The pilot flying pushed the control column forward immediately after stick shaker activation and put the aircraft into a descent.

He applied a part of the recovery from approach to stall procedure recommended by the airline by pushing on the control column to stop the stick shaker.

The crew never applied TOGA thrust, corresponding to 117.5% of N1, as recommended by the FCOM.

The airplane never passed a height of 400 feet.

The radio altimeter called out the descent heights from 300 feet down to 10 feet.

The stall warning did not correspond to a true stall situation.

The GPWS warnings were activated but were not generated in the cockpit because they were not prioritized in comparison to the successive stall and overspeed warnings.

The VFE overspeed warning was generated one and a half seconds before the impact.

The Captain realized how low the plane was and gave the order to climb one second before the impact.

The airplane collided with the sea with a slight nose down attitude at a speed increasingly above VFE.

The airplane's flight path was probably controlled by the crew until the impact with the sea.

3.2 Causes of the accident

The Commission of Inquiry concluded that the cause of the accident to flight KQ 431 on 30 January 2000 was a collision with the sea that resulted from the pilot flying applying one part of the procedure, by pushing forward on the control column to stop the stick shaker, following the initiation of a stall warning on rotation, while the airplane was not in a true stall situation.

In fact, the FCOM used by the airline states that whenever a stall warning is encountered at low altitude (stick shaker activation), it should be considered as an immediate threat to the maintenance of a safe flight path. It specifies that at the first sign of an imminent stall or at the time of a stick shaker activation, the following actions must be undertaken simultaneously: thrust levers ion TOGA position, reduction of pitch attitude, wings level, check that speed brakes are retracted. The investigation showed that the pilot flying reduced the pitch attitude but did not apply TOGA thrust on the engines. The investigation was unable to determine if the crew performed the other two actions: leveling the wings and checking that the speed brakes were retracted.

The following elements contributed to the accident:

- the pilot flying's action on the control column put the airplane into a descent without the crew realizing it, despite the radio altimeter callouts;
- the GPWS warnings that could have alerted the crew to an imminent contact with the sea were masked by the priority stall and overspeed warnings, in accordance with the rules on the prioritization of warnings;
- the conditions for a takeoff performed towards the sea and at night provided no external visual references that would have allowed the crew to be aware of the direct proximity of the sea.

4 - SAFETY RECOMMENDATIONS

4.1 Management of the stall warning

The various possible accident scenarios were examined by the Commission of Inquiry. The stall warning was initiated at the end of the rotation, when the airplane was not in a stall situation and was in a normal takeoff configuration. The crew reacted to the warning by reducing the pitch attitude, which caused the airplane to descend until impact with the sea.

In case of stick shaker activation, the procedure recommended by the manufacturer and applied by the operator in fact consists of simultaneously applying TOGA thrust on the engines and reducing the pitch attitude, leveling the wings and checking that the speed brakes are not extended. The procedure specifies that if there is a risk of ground contact, the pitch attitude must not be reduced more than necessary, in order to allow the speed to increase.

It appears that, in the case of a false alarm, the application of this procedure does not necessarily lead to the stick shaker stopping. This is what happened on the day of the accident.

This remark is not limited to the A310. For all public transport aircraft there is a real probability that a false stall warning may appear during a critical phase of flight, at a low height.

Consequently, the Commission of Inquiry recommended, on 9 August 2001, that Civil Aviation Authorities ask training organizations and operators under their authority to integrate into type rating and recurrent training programs, for crews of all aircraft likely to be subject to false stall warnings, the elements necessary to recognize and manage such a false alarm during phases of flight close to the ground.

The Commission of Inquiry confirms this recommendation, whose objective is, firstly, to sensitize flight crews to the possibility of such a false alarm appearing and, secondly, to modify the procedures for managing a stall warning during phases of flight close to the ground.

4.2 Harmonization of operational procedures

During the investigation, the Commission learnt that a new recovery from approach to stall procedure was being taught at Airbus Training, published after the accident. This new procedure is different from that recommended in the FCOM and used by the airline. In fact, in the new Airbus ⁽⁶⁾ Flight Crew Training Manual, December 2000 revision, chapter 1.03.27, “unusual procedures“, “flight controls” and “recovery from approach to stall”, included in appendix 17, it is stated that:

- at stick shaker activation, even with reduced lift margins, an aircraft still has positive performance capability. So, instead of trying to recover in minimum time by power application and pitch down, the technique recommended is a minimum loss of altitude by power application and flying optimum pitch;
- the Flight Path Vector (FPV) can be of great help in controlling flight path so as to minimize the height loss during recovery. Pitch attitude should then be adjusted to hold FPV on or close to the horizon;
- use the maximum thrust allowable. Pitch up is noticeable with thrust application, move the control column to smoothly adjust the pitch attitude as necessary during the recovery. Avoid abrupt control inputs, they may induce a secondary stall;
- the recovery procedures are described for a smooth configuration at an altitude above 20,000 feet and for a smooth configuration and a landing configuration at an altitude below 20,000 feet.

Thus, the procedures currently taught by Airbus Training insist on the fact that pilots should not try to minimize the time for the recovery from the stall by acting on the thrust and the pitch attitude, but rather recommending by minimizing the loss of altitude by applying maximum thrust and flying optimal pitch. Below 20,000 feet, the pitch attitude recommended is 10 degrees pitch up.

This procedure is different from that applied within the airline and that described in the FCOM.

⁶ The Aéroformation training center is now called the Airbus Training Center

Consequently, the Commission of Inquiry recommends that:

- the French DGAC ensure that Airbus harmonizes the procedures in the FCOM with those taught during type rating training.

4.3 Rescue operations

The Abidjan Airport emergency plan was applied as soon as the accident occurred.

The investigation showed the difficulties encountered in organizing the sea rescue operations. The characteristics of Abidjan Airport are not an isolated case. These characteristics are representative of the majority of coastal airports with high traffic. All airports have permanent ground equipment for search and rescue on a permanent state of alert during opening hours. However, the majority of airports on the coast or near water do not have maritime rescue equipment available allowing for such operations to be undertaken in the area around coastal airports.

Consequently, the Commission of Inquiry recommends that:

- civil aviation authorities responsible for coastal airports or those near water ensure that appropriate equipment (aerial, maritime, etc.) be put in place so as to ensure immediate intervention at an accident site located in an area near a coastal airport.

Report adopted in Abidjan on 25 January 2002

The President, representing the
Minister of Transport

The Secretary

EZALEY Georges Philippe,
Civil Aviation Engineer, Director
General of SODEXAM

ABONOUAN Kouassi Jean,
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Representative of the Minister
of Public Health and Social
Protection

Doctor SISSOKO Jacques,
Director of SAMU

Representative of the Minister
of State for Defense

Colonel MONNET Antoine

List of Appendices

Note: The appendices available with this report are the originals. Some of them are in English while others are in French.

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Adoption of the report

Appendix 2

Composition of the Commission of Investigation, the Technical Committee and the participants in the working groups.

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Appendix 16

Case study of stall warning activation without a real stall situation having occurred

Appendix 17

New Airbus Crew Training Manual, December 2000 version, chapter 1.03.27

ANNEXE 1
ADOPTION DU RAPPORT

ANNEXE 1A
RAPPORT D'ADOPTION

REPUBLIQUE DE COTE D'IVOIRE

MINISTRE DES TRANSPORTS

COMMISSION D'ENQUETE SUR L'ACCIDENT DE KENYA AIRWAYS

**ADOPTION DU RAPPORT FINAL DE L'ENQUETE
SUR L'ACCIDENT SURVENU LE 30 JANVIER 2000 A L'AIRBUS A310-304
IMMATRICULE 5Y-BEN EXPLOITE PAR LA COMPAGNIE KENYA AIRWAYS
APRES SON DECOLLAGE DE L'AEROPORT D'ABIDJAN**

Le 30 janvier 2000 à 21 h 10 GMT, l'A310 Immatriculé 5Y-BEN appartenant à Kenya Airways, assurant le vol KQ 431 s'est écrasé en mer peu après le décollage de l'Aéroport d'Abidjan, avec à son bord 179 personnes. L'appareil a été détruit. 169 personnes sont décédées ou portées disparues et 10 ont survécu. L'avion décollait d'ABIDJAN pour LAGOS puis NAIROBI.

Conformément à la Convention de Chicago relative à l'Aviation Civile Internationale, la Côte d'Ivoire, pays d'occurrence, a ouvert une enquête technique pour déterminer les circonstances, rechercher les causes et tirer les enseignements afin de prévenir de futurs accidents.

En application de la Convention de Chicago, le projet de rapport établi par le pays d'occurrence a été transmis, pour observations, au Kenya, Etat dont relève l'exploitant et à la France, Etat dont relève le constructeur, avant la publication du rapport final.

Les observations de ces Etats ont fait l'objet de séances de travail technique à ABIDJAN, du 21 au 23 janvier 2002, puis d'une séance d'adoption les 24 et 25 janvier 2002.

La liste des participants à la séance d'adoption figure en annexe.

A l'ouverture de la séance, le Président de la Commission d'enquête a indiqué que l'enquête a été menée à terme grâce à la coopération du Canada pour l'utilisation de son laboratoire pour le dépouillement des boîtes noires, de la France pour la recherche des enregistreurs de bord, les travaux supplémentaires sur les boîtes noires, la prise en charge financière des opérations de cartographie sonar et opérations d'observations sous-marines de l'épave, enfin du Kenya pour la mise à la disposition de la Commission d'enquête d'une donation pour le financement de certaines activités de l'enquête.

Ensuite, le Coordinateur a présenté la démarche suivie pour la conduite de l'enquête, le projet de rapport et les conclusions des séances de travail technique du 21 au 23 janvier 2002, dont deux points restaient ouverts.

Le Représentant accrédité du Kenya a dit que son pays, sur le principe était satisfait du rapport et l'adoptait, sous réserve de la réponse d'AIRBUS concernant le TOGA et l'amélioration de la rédaction de la recommandation 4.3 sur les secours.

Le Représentant accrédité de la France a donné les informations sur le TOGA, après avoir contacté AIRBUS, suivies d'un long débat et a indiqué qu'il acceptait les corrections apportées par les séances de travail techniques mais que son pays voulait que les secours soient analysés dans le rapport.

Le Président de la Commission a proposé que les causes de l'accident soient mieux reflétées dans le rapport. Il a précisé que le rapport avait été établi conformément aux normes et pratiques recommandées de l'OACI et pour ce qui concerne les secours des informations très détaillées ont été fournies dans le rapport, alors que l'annexe 13 demandait de faire une description succincte des secours. Une recommandation a été proposée à la communauté internationale sur les questions de secours au niveau des aéroports côtiers. La Côte d'Ivoire a proposé que les différentes parties puissent améliorer la rédaction des secours dans la première partie du rapport et la recommandation y relative, au cours d'une réunion prévue le 25 janvier 2002, à 09 heures.

A cette réunion, étaient présentes les délégations française et ivoirienne qui ont pu valider les dernières corrections à apporter au rapport. La France et le Kenya n'ont pas proposé d'amélioration sur les secours.

Au cours de la réunion plénière de l'après-midi, le Représentant accrédité de la France a indiqué qu'il était satisfait du rapport. Il a ensuite présenté ses observations portant sur l'analyse des secours et demandé qu'elles soient incorporées en annexe au rapport. De même, le Représentant accrédité du Kenya a indiqué qu'il était satisfait du rapport. Il a aussi présenté ses observations portant sur les secours et demandé une réponse écrite d'AIRBUS sur la question du TOGA et demandé qu'elles soient incorporées en annexe au rapport.

Sur cette base, le rapport final d'enquête a été adopté.

Fait à ABIDJAN, le vingt cinq janvier de l'an deux mille deux, ont signé :

Pour la France

Pour la Côte d'Ivoire

Pour le Kenya





Arnaud TOUPET
Représentant accrédité

EZALEY Georges
Président de la Commission

Peter WAKAHIA
Représentant accrédité

ANNEXE 1BOBSERVATIONS DE LA FRANCE ET DU KENYA

Ministère de l'Équipement
des Transports et du Logement



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BEA

Bureau d'Enquêtes et d'Analyses
pour la Sécurité de l'Aviation Civile

Le Bourget, le 25 janvier 2002

**Observations de la France sur le projet de rapport sur l'accident du SY-BEN
survenu à Abidjan le 20 janvier 2000**

Ayant pris connaissance du projet de rapport final sur l'accident du SY-BEN, la France regrette que ce rapport ne comporte pas une analyse complète de l'organisation des secours. Pour être comprise puis mise en œuvre par les organismes concernés, il est en effet nécessaire que la recommandation sur les secours soit étayée par une analyse préalable mettant en évidence les problèmes spécifiques rencontrés et les améliorations souhaitables.

L'absence d'une telle analyse n'est pas conforme à l'esprit de l'enquête technique dont le but est l'amélioration de la sécurité de l'Aviation Civile. En effet, cette absence d'analyse prive la communauté aéronautique internationale d'importants éléments d'information.

L'amélioration de la sécurité de l'aviation ne consiste pas seulement à éviter l'occurrence d'un accident mais également à limiter les conséquences d'un accident en terme de victimes. Les secours jouent un rôle important sur ce dernier point. Ceci est d'autant plus important que l'enquête a montré que plusieurs personnes sont décédées par noyade après avoir survécu à l'impact de l'avion avec la mer.

La France demande que ces observations soient annexées au rapport final.

D'origine : Bureau de l'Aviation Civile
Chef du Bureau Enquêtes Accidents

P. ARSLANIAN

MINISTRY OF INFORMATION, TRANSPORT AND COMMUNICATIONS
AIRCRAFT ACCIDENT INVESTIGATIONS BRANCH

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OFFICE OF THE MINISTER
P.O. Box 30163
NAIROBI, KENYA

Date

Your Ref.

Our Ref. CAV/
5Y-BEN

18 June 2002

**TO THE COMMISSION OF INVESTIGATION
KENYA AIRWAYS KQ-431 5Y-BEN**

**SUBMISSION OF THE REPUBLIC OF KENYA FOR INCLUSION IN
THE ACCIDENT REPORT TO KQ-431 REGISTERED 5Y-BEN**

In accordance with the provisions of Annex 13 to the ICAO Convention, the Republic of Kenya wishes to register differences with the report on accident to KQ-431, 5Y-BEN. The Republic of Kenya wishes to have the following appended to the report:-

A. SEARCH AND RESCUE

"It is the considered understanding of the Republic of Kenya that the report on all aspects of search, rescue, recovery and security has not been accorded the review/analysis as it relates to fact, detail and appropriate recommendation."

B. CONCLUSIONS

"It is the considered understanding of the Republic of Kenya that procedures for use/application of TOGA power during flex take-off with landing gear down have not been exhaustively researched and analysed to justify inclusion in the conclusions."

Yours Faithfully,

Peter M. Wakahia
ACCREDITED REPRESENTATIVE

ANNEXE 1C

NOTE SUR LES OBSERVATIONS

A la date de publication du rapport final, la Côte d'Ivoire présente les commentaires suivants, sur les observations faites par les représentants accrédités de la France et du Kenya.

1. Sur les secours

L'enquête a été conduite conformément aux dispositions de la Convention de Chicago. En particulier, pour ce qui concerne l'analyse des secours, les dispositions de l'Annexe 13 ont été respectées ; notamment, les définitions et l'objectif d'une enquête sur un accident ont été exploités. Ainsi, l'appendice B de l'Annexe 13 : **modèle de présentation du rapport final** indique que :

- paragraphe 1.15 : **Questions relatives à la survie des occupants.** Brève description des recherches, de l'évacuation et du sauvetage des membres d'équipage et des passagers, ainsi que l'emplacement où ils se trouvaient, en relation avec les blessures subies et les défaillances d'éléments de structures ;
- paragraphe 2 : **Analyse.** Analyser seulement les renseignements qui sont indiqués dans les renseignements de base et qui se rapportent à la détermination des conclusions et des causes.

Le rapport final a fait, sur 5 pages, un long développement des questions relatives à la survie des occupants. Aussi, conformément à ce qui précède, l'Analyse a porté seulement sur les renseignements de base qui se rapportent à la détermination des conclusions et des causes.

2. Sur le TOGA

Le Kenya demande une réponse écrite d'Airbus sur le fait qu'en cas de décollage à poussée réduite, il est possible d'avancer les manettes et d'obtenir la poussée maximum (TOGA), avec le train sorti.

Pour ce faire, des correspondances ont été échangées. Il s'agit de :

- la requête du représentant accrédité de la France auprès d'Airbus ;
- la réponse d'Airbus, ainsi que la copie du Flight Crew Training Manual (aug 89) ;
- la réponse du Kenya.

Ces lettres figurent en appendice à cette note.

Ministère de l'Équipement
des Transports et du Logement



Bureau d'Enquêtes et d'Analyses
pour la Sécurité de l'Aviation Civile

Le Bourget, le 25 janvier 2002

N° : BEA

Monsieur Kwok Chan
Airbus flight safety
Technical Advisor of France
fax : 00 33 5 61 93 44 29

Objet : Accident du vol KQA 431 à Abidjan (SY-BEN)

Vnt :

P.J. : 1

Dear Mr Chan,

A technical question has been arisen by Kenya during the report adoption meeting today. They would like Airbus to officially answer this question today to avoid to have to append this comment to the final report. It concerns the application of TOGA power after take off. The question is : in the configuration of the day of the accident, a flex take off, was it possible for the crew to apply TOGA only by pushing the thrust levers or by lifting the go levers to obtain the maximum power ? If not, what were the different necessary actions that the crew had to perform in order to obtain the maximum power.

Please answer immediately by fax at the following number : 00 225 21 27 73 71 or 00 225 21 27 53 46.

Best regards

Arnaud Toupet

Représentant Accrédité,
Enquêteur Technique BEA

BRIEFING NOTES (CONT'D)

APPROACH TO STALL

I - GENERAL

On modern jet aircraft available power and the need for consistency between stall and windshear manoeuvres, lead to a different technique than the one used on light aircraft.

The key factor is that, at stick shaker activation, even with reduced lift margins, an aircraft still has positive performance capability. So, instead of trying to recover in minimum time by power application and pitch down, the technique now recommended is for a minimum loss of altitude by power application and flying optimum pitch.

II - OPERATIONAL BACKGROUND

2.1. GENERAL

VS is defined as the minimum steady flight speed demonstrated at an entry rate of 1 Kt per second, at zero thrust.

Stall warning is considered to be any warning readily identifiable by the pilot, either artificial (stick shaker) or natural (buffet).

Recovery from an approach to stall will be initiated at the earliest recognizable stall warning indication.

2.2. STALL CHARACTERISTICS

In clean and 15/0 configurations, the stall is identified by heavy and irregular buffet.

To prevent excessive α with flaps selected to 15° and beyond, the Feel Limitation Computer (FLC) doubles the force required for any given stick displacement and hence to move the stick forward to the neutral elevator position. The resulting pitch down provides artificial stall identification.

With the flaps at, or beyond, 20°, α trim is also used as the aircraft exhibits little natural stability in these configurations.

BRIEFING NOTES (CONTD)

APPROACH TO STALL (CONTD)

2.3. FLC AND α TRIM PROTECTION

Both systems are fully duplicated. Any combination of systems engaged will give complete protection (FLC1, α trim 2, etc...)

FLC operates at about 23° α with phase advance.

α Trim operates at about 21° α with phase advance.

The phase advance is limited to inhibit any triggering of FLC or α trim before stick shaker which is activated for a fixed value of 17°5

α Trim winds on 4° nose down stabilizer in 3 seconds.

As α reduces 2° below triggering threshold, FLC action stops and α trim winds off

If the speed loss occurs with AP engaged and both ATS disarmed, the AP will continue to trim below VLS. When the stall occurs, the elevator will therefore be at, or close to, neutral and the FLC will not then provide any significant protection.

III - TECHNIQUE

3.1. ENTRY

Set ATS levers to OFF.

Set power to idle and adjust the pitch to maintain a deceleration rate of 1 Kt per second, using a target speed trend of 10 Kt down.

Do not trim below VLS.

3.2. RECOVERY

A) No risk of ground contact

At the first indication of stall or stick shaker, trigger go levers, advance thrust levers to maximum thrust, smoothly set a safe pitch attitude (approximately 12°5) above the horizon and level the wings, if aircraft is in clean configuration and below 20.000 ft immediately select Slats 15°, respect stick shaker and disregard FD bars..

BRIEFING NOTES (CONT'D)

APPROACH TO STALL (CONT'D)

If possible, select FPV on and use as described in 3.2 below. As the aircraft accelerates, continue to adjust pitch attitude as required minimizing altitude loss and return to VLS. At VLS and not before, if in landing configuration, retract Flaps one stage continue as for normal go-around. In all cases clean up as required at F and S.

At altitude above 20,000 ft, a lower pitch attitude is required to achieve acceptable acceleration. At these altitudes, zero pitch or lower may be necessary.

B) Risk of ground contact

At the first indication of stall or stick shaker, trigger go levers, advance thrust levers to maximum thrust, level the wings and smoothly adjust pitch attitude as necessary to minimize altitude loss and avoid the terrain, if aircraft is in clean configuration and below 20,000 ft immediately select Slats 15°, (maximum pitch 12°5 clean or 17°5 with slats).

As long as there is a risk of ground contact, allow IAS to decrease to VSS if necessary, but NOT below. Respect stick shaker and disregard FD bars. If possible, select FPV on and use as described below, or select FD off.

Attempt to control pitch as smoothly as possible. Avoid abrupt control inputs since they may induce a secondary stall.

When there is no longer a risk of ground contact, slightly lower the nose to begin acceleration. As the aircraft accelerates, continue to adjust pitch attitude as required and return to maneuvering speed. At VLS and not before, if in landing configuration, providing recovery is complete (positive rate of climb and acceleration), retract Flaps one stage, and continue as for normal go-around. In all cases clean up as required at F and S.

All recoveries from approach to stall are performed as if an actual stall has occurred.

Recovery is considered completed when VLS is reached with a positive rate of climb or a positive speed trend in level flight.

BRIEFING NOTES (CONT'D)

SUMMARY1. No risk of ground contact

- Full power - trigger go levers and push throttles full forward
- Pitch - Smoothly select safe pitch attitude (12°5). Level wings
- At the same time, if clean, select slats 15° (below 20000 FT)
- As aircraft accelerates adjust pitch attitude as required minimizing altitude loss
- Clean up

2. Risk of ground contact

- Full power - trigger go levers and push throttles full forward
- Pitch attitude as necessary to minimize altitude loss and avoid terrain
- At the same time slats 15° if clean (below 20000 FT)
- Respect stick shaker-minimum speed to avoid ground contact VSS
- When risk of ground contact removed accelerate and clean up

3.3. FPV

The FPV can be of a great help in controlling flight path so as to minimize the height loss during recovery. Pitch attitude should be then adjusted to hold FPV on or close the horizon.

BRIEFING NOTES (CONT'D)

3.4 LATERAL AND DIRECTIONAL CONTROL

Lateral control is maintained with ailerons and spoilers, which remain effective throughout the manoeuvre.

Rudder control should not be used to help maintain wings level.

A rudder input will cause yaw, and the resulting roll due to yaw is undesirable.

If roll exists at start of exercise, level the wings smoothly to avoid (or limit) spoilers extension.

3.5 THRUST

During the recovery, advance thrust levers to the maximum allowable thrust.

Pitch up is noticeable with thrust application. Move the control column to smoothly adjust the pitch attitude as necessary during the recovery. Use pitch trim as necessary.

3.6 LANDING GEAR

If the entry is made with the landing gear extended, do not retract it until recovery has been completed. Gear sequence (doors + gear) induces undesirable drag, which leads to a transient reduction of climb angle of approximately 1°.

3.7 FLAPS

Retracting the flaps from the landing position is not recommended, especially when near the ground, as a greater altitude loss will result during the recovery.

Slat extension is not permitted above 20,000 ft.

Below 20,000 ft, slats will be extended to 15° to provide additional margin above stall speed.

4 - AUTO FLIGHT SYSTEM

Before starting an approach to stall recovery exercise, ATC will be disarmed to avoid THR L engagement.

When go levers are triggered, they normally engage GO AROUND mode, and reset the FD bars even if the FPV was used. In the clean configuration however, this does not occur; only THR L would engage if ATS has not been disarmed.

In go around mode, FD bars command the FCU selected speed ± 10 kt, limited to 15° pitch maximum or 100 fpm minimum. These commands are not optimum for stall or windshear recovery. So, go levers will be activated only for consistency with the go around manoeuvre.

BRIFING NOTES (END)

DUTCH ROLL

The A310/A300-600 lateral dynamic stability is positive without yaw damper. It is possible to dispatch the aircraft with both yaw dampers inoperative, without any restriction.

However to improve the passenger comfort and to allow easier handling at high altitude, the A310/A300-600 is provided with two yaw dampers.

For Dutch roll recovery demonstration set both yaw dampers to OFF.

- 1) PNF gives a kick on rudder (about half travel);
- PF damps the dutch roll using ailerons only.

- 2) After stabilization

PNF kicks again in the same way;

PF lets the airplane stabilize hands off the controls (natural damping).

NEVER USE RUDDER FOR THE RECOVERY AS ANY SIDE SLIP WILL INCREASE DUTCH ROLL.

MACH TRIM

Mach Trim active only in clean configuration

When MACH increases the center of lift (pressure point) moves rearwards. This leads to a nose down movement.

In order to improve the static aircraft stability the mach trim will automatically and slowly trim nose up. Mach trim works beyond 0.7 Mach (maximum authority 0.7° Pitch up).

VC Trim (Speed trim) active in all configuration.

VC Trim improves the static aircraft stability by varying the stabilizer position for speed above 200 kt up to 380 kt (maximum authority 0.8° Pitch up).

ALPHA TRIM EFFECT

Active only without AP engaged.

Activation:

- in clean configuration (if no AP engaged - No speed brakes) is function of angle of attack and Mach number; nose down auto trim counters pitch up tendency.
- in F 20 or F 40 config; above 21° of angle of attack at low speed; nose down auto trim will avoid excessive angle of attack (A310). For A300-600 it is active in G 15°, F 15°, F 20° configuration (maximum authority 4° Pitch down).

This function improves longitudinal static stability by nose down automatic trim.

This demonstration is more noticeable at high altitude and high Mach number by increasing the angle of attack (pitch and bank).

REPUBLIC OF KENYA



MINISTRY OF TRANSPORT AND COMMUNICATIONS

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P. O. BOX 30163
NAIROBI, KENYA

FACSIMILE TRANSMISSION

TO: INVESTIGATION 5Y-BEN
ATTN: Nogbou Say Simon, Co-ordinator,
FAX NO: 225 21 27 73 71
FROM: AIRWORTHINESS DIVISION
DATE: 19th March, 2002
OUR REF. 5Y- BEN

Dear Sir,

RE: INFORMATION ABOUT TOGA FROM AIRBUS

I am in receipt of your fax of 14/2/2002 on the above subject.

I am afraid we did not receive the correspondence you sent through the Kenya Airways representative in Abidjan. As we mentioned earlier, the fax communication you had sent to us was not legible; therefore we could not reply to you.

The question we had requested of Airbus was about interpretation; more than the reference you have sent us. Please go through our comment during the meeting in Abidjan and let Airbus address it accordingly in order to resolve this question.

Please accept the assurances of our highest consideration.

Yours faithfully,

A handwritten signature in dark ink, appearing to be 'P. M. Wakahla'.

P. M. Wakahla
Chief Inspector of Accidents.

ANNEXE 2

COMMISSION D'ENQUETE, COMITE TECHNIQUE ET GROUPES DE TRAVAIL

1. COMMISSION D'ENQUETE

La Commission d'enquête, désignée par arrêté du 22 mars 2000, du Ministre d'Etat chargé des Infrastructures et des Transports, avec mission de déterminer les circonstances, rechercher les causes et tirer les enseignements de l'accident était composée comme suit :

Président

Monsieur EZALEY Georges Philippe, Ingénieur de l'Aviation Civile, Directeur Général de la SODEXAM, représentant le Ministre des Transports

Secrétaire

Monsieur ABONOUAN Kouassi Jean, Juriste en Transport Aérien, Directeur de l'Agence Nationale de l'Aviation Civile (ANAC)

Membres

- Monsieur BOUIKALO-BI Youzan Raymond, Commissaire de Police, Sous-Directeur de la Police de l'Air et des Frontières, représentant le Ministre d'Etat chargé de la Sécurité ;
- Docteur SISSOKO Jacques, Directeur du SAMU, représentant le Ministre de la Santé Publique et de la Protection sociale ;
- Monsieur COULIBALY Mohamed Vabé, Magistrat, Sous-Directeur des Affaires Civiles et du Sceau, représentant le Ministre de la Justice, Garde des Sceaux ;
- Colonel MONNET Antoine, représentant le Ministre d'Etat chargé de la Défense.

En outre, en application des dispositions de l'Annexe 13 de la Convention de Chicago, des Représentants accrédités de l'Etat d'immatriculation et de l'Etat constructeur ont été admis à participer aux travaux de la

Commission d'enquête. Ainsi, le Kenya, Etat d'immatriculation a désigné Monsieur Peter WAKAHIA, Inspecteur à la Direction de l'Aviation civile et la France, Etat constructeur, Monsieur Arnaud TOUPET, enquêteur du BEA.

2. COMITE TECHNIQUE

Le Comité technique, désigné par arrêté du 22 mars 2000, du Ministre d'Etat chargé des Infrastructures et des Transports, avec mission de mener l'enquête et de soumettre les conclusions de ses travaux à la Commission d'enquête pour examen et adoption était composé comme suit :

Président

Monsieur ABONOUAN Kouassi Jean, Juriste en Transport Aérien, Directeur de l'Agence Nationale de l'Aviation Civile (ANAC)

Coordinateur

Monsieur NOGBOU Say Simon, Ingénieur de l'Aviation Civile, Directeur à la SODEXAM

Coordinateur Adjoint

Madame SEKA GNASSOU Irène, Ingénieur de l'Aviation Civile, Conseiller Technique en Transport Aérien au Ministère des Transports

Rapporteurs

Monsieur KAKO Doma Laurent, Ingénieur des Techniques de l'Aviation Civile, Spécialiste de la prévention et des enquêtes sur les accidents d'aviation, Chef du Département Sécurité des Vols à l'ANAC

Monsieur GONH Pierre, Ingénieur des Techniques de l'Aviation Civile, Chef du Département Contrôle Technique et Entretien des aéronefs à l'ANAC

Membres

Monsieur N'CHOT Yapi Michel, Ingénieur des Techniques de l'Aviation Civile, Chef de service de la Circulation Aérienne à la SODEXAM

Monsieur N'GOM Souleymane, Inspecteur du Bureau de Contrôle en Vol (BCV) à l'ANAC, Enquêteur Technique d'accident d'aviation, Commandant de bord A310 à AIR AFRIQUE

Monsieur YAO Dapré, Ingénieur des Techniques de l'Aviation Civile, Chef de service Navigation Aérienne à la Représentation de l'ASECNA en Côte d'Ivoire

Monsieur SOUMAHORO Yaya, Ingénieur de l'Aviation Civile, à la Représentation de l'ASECNA en Côte d'Ivoire

Docteur TANOHO Koutoua, Médecin, Chef du Service Médical de l'Aviation Civile à l'ANAC

Docteur KACOU François-Xavier, Médecin, Directeur du Centre de Médecine Aéronautique et Aéroportuaire à la SODEXAM

Colonel N'GORAN Niamien Barthélemy, Pilote de ligne aux Forces Aériennes de Côte d'Ivoire

Capitaine de Frégate AKAKO Alia Gomis, Commandant du BSC le Vigilant de la Marine Nationale de Côte d'Ivoire

Monsieur AKOLEY Kodjo, Chef de Service Audit à la Compagnie multinationale AIR AFRIQUE

3. GROUPES DE TRAVAIL

Outre les membres du Comité Technique, des spécialistes d'AIR AFRIQUE, de la Direction de l'Aviation civile du Kenya, du Bureau de la Sécurité des Transports du Canada, du Bureau Enquête Accidents de France, d'AIRBUS, de GENERAL ELECTRIC et de KENYA AIRWAYS ont travaillé dans un des trois groupes de travail.

ANNEXE 3
REPARTITION DES VICTIMES PAR NATIONALITE

Cent soixante huit (168) victimes décédées étaient ressortissantes de 33 pays différents qui figurent dans le tableau suivant. La nationalité d'une (1) victime décédée n'a pas été déterminée.

Etat	Nombre
Nigeria	84
Kenya	20
Inde	8
Congo	5
Ouganda	5
Madagascar	4
Sénégal	3
Togo	3
Canada	2
Côte d'Ivoire	2
Etats-Unis d'Amérique	2
Ethiopie	2
France	2
Ghana	2
Iran	2
Mali	2
Pays-Bas	2

Etat	Nombre
Philippines	2
Rwanda	2
Zambie	2
Belgique	1
Burkina Faso	1
Burundi	1
Espagne	1
Gambie	1
Guinée	1
Irlande	1
Libéria	1
Mauritanie	1
Tanzanie	1
Tchad	1
Zimbabwe	1
Nationalité indéterminée	1
TOTAL	169

ANNEXE 4

SYSTEME GPWS

Le système GPWS comprend :

- un calculateur GPWS
- deux lampes d'alarme GPWS et G/S respectivement rouge et ambre sur le panneau d'instrument du pilote et du Copilote
- un système d'alarme auditive

Les alarmes visuelles et auditives peuvent se déclencher entre 30 et 2450 pieds de hauteur.

Les modes et les alarmes sonores correspondant au GPWS installé sur l'avion sont les suivants :

- **Mode 1** : Excessif Sink Rate (taux de descente excessif) avec audio « Sink Rate » puis « Whoop Whoop Pull up » et lampe rouge GPWS
- **Mode 2** : Excessive Terrain Closure Rate (taux de rapprochement avec le sol excessif) avec audio « Terrain Terrain » puis « Whoop Whoop Pull up » et lampe rouge GPWS
- **Mode 3** : Descent after Take off (descente après décollage) avec audio « Don't sink » puis « Too low terrain » et lampe rouge GPWS
- **Mode 4A** : Inadvertent Proximity to Terrain (proximité avec le sol inopinée) train rentré avec audio «Too low Gear» puis « Too low terrain » et lampe rouge GPWS
- **Mode 4B** : Inadvertent Proximity to Terrain (proximité avec le sol inopinée), train sorti avec audio «Too low Flaps» puis « Too low terrain » et lampe rouge GPWS

- **Mode 5** : Descent below ILS Glide Slope (descente sous le plan de l'ILS) avec audio « Glide Slope » et lampe ambre G/S

Les alarmes GPWS apparaissent par ordre de priorité suivant :

- 1- Whoop Whoop Pull up
- 2- Terrain Terrain
- 3- Too low terrain
- 4- Too low Gear
- 5- Too low Flaps
- 6- Sink Rate
- 7- Don't sink
- 8- Glide Slope

Toutes les alarmes auditives du GPWS peuvent être annulées en pressant le bouton EMER AUDIO CANCEL. Toutes les alarmes GPWS sont inhibées lorsque l'alarme de décrochage est active [B1].

ANNEXE 5 remarques inscrites sur les CRM et actions de maintenance

CRM

ATA 23/34 (Communications/Navigation)

Date	AML	Réponse
26/01/99	N° 1 A/P u/s requires pitch trim actuator PN 30 513-136	ADD still outstanding due nil spares
01/01/00	Pitch trim n° 1 fault + Yaw damper n° 1 fault	Ground scan shows no failures. N° 1 FCC and n° 1 FAC C/BS cycled. Pitch trim n° 1 and yaw damper n° 1 engagement checks satisfactory
04/01/00	Pitch trim 2, ATS 1 not latching. F/O FD not available either	96GB and 141GB nose landing gear relays swapped. Pitch trim 2, ATS 1, and F/Os FD all function OK. AFS/LND test carried out OK
06/01/00	ADC n° 1 fault. Pitch and yaw n° 1 wont latch, speed band lost	ADC n° 1 replaced functioned OK
20/01/00	On APU start pitch trim n° 1 and yaw damper n° 1 trip off. Unable to reset there after.	AFS land test carried shows no failure last flight. Engagement of pitch 1 and yaw damper 1 checked OK.
25/01/00	1°) Pitch trim 1 will not engage, 2°) pitch trim 1 + yaw damper 1 will not engage, 3°) FAC 1 failure	1°) A/P fault record FCC1 failed FAC 2 failed, ADC 1 flag reset checked on grd engaging OK, 2°) last flight leg 3 record : TCC2 transient flag, FCC 2 transient flag, FAC 1 transient flag, 3°) FAC reracked checked OK

ATA 27 (Contrôles de vol)

Date	AML	Réponse
26/01/99	ADD n° 22 : N° 2 and 3 spoilers deactivated due n° 2L fault n° 2 EFCU Code M2-4 suspect defective n° 2L actuator	Actuator replaced OFF : S/N W152 ON : W404 EFCU replaced OFF : S/N 1172 ON : 1270

ATA 28 (Carburant)

Date	AML	Réponse
10/01/00	CGCC functioned for the first 6 hours of the flight only (Regular problem) (08H18 de vol)	CGCC reset / Fuel recirculation performed / Water drains carried out
12/01/00	1°) Fuel fault light on mode selector of fuel panel "ON" on ECAM fuel page, 2°) Please transfert all the fuel into the ctr tank during long stay over time, 3°) Both left inner fuel pumps faulty	1°) CGCC reset performed, 2°) Transferred all fuel into center tank, 3°) Fuel transferred to center tank and more uplifted for CAI-NBO sector
13/01/00	Both left inner tank pumps faulty during autofeeding when logic is for inner tanks to feed engines. This started during cruise but persisted on descent. (Note : Page 122628 the same snag caused diversion to CAIRO)	Both inner tank fuel boost pumps tested. Found working OK. Pressure sensor plugs cleaned and dried with nitrogen. Pumps check for operation OK
14/01/00	1°) Reset CGCC, 2°) Left inner fuel pumps 1 and 2 u/s intermitently, 3°) CGCC u/s after only 3 hours flight (Vol de 08H08)	Reseted CGCC, 2°) Fuel recirculated. Water drained from all tanks [...] OK, 3°) Reset
15/01/00	L/H Outer pump n° 1 u/s	Fuel recirculated from outer to inner and waterdrain carried out on all fuel tanks. Pump checked OK.
20/01/00	1°) CGGC failed after 3 hours of flight (04H44 de vol). Aft transfert not available. Suspect water, please drain and monitor, 2°) When the inner fuel tanks are empty the logic does not transfer to center but consumes the outer tank fuel. Pumps must be switched off to consume the center tank.	1°) Water drain carried from all fuel tanks. Fuel recirculated around. CGCC reset, 2°) FQI and CGCC reset OK. Also fuel level amp reracked.
21/01/00	1°) Drain water from center and trim tanks about 1 ton or unusable fuel indicated, 2°) Note CGCC fault after 7 H of flight (Vol de 09H18)	1°) Water drained from centre, inners and trim tanks, 2°) CGCC reset OK

ATA 32 (Train d'atterrissage)

Date	AML	Réponse
20/01/00	Tail skid needs to be repainted again, 2°) On ground, turns to the left triggers the landing Gear unsafe warnings with Continuous Repetitive Chime. Plse investigate and rectify	1°) ADD n° 12 raised tail skid to be painted with enough ground time, 2°) Proximity detector box has no fault codes recorded. Computer reset and tightend. Prox detectors inspected for security "Satisfactory"

DOSSIER DE VISITE

L'examen des dossiers de visite indique des actions de maintenance effectuées sur le sabot de queue et la reverse du moteur N°1 ; notamment comme suit :

ATA 25 (Equipement/Aménagement)

Date	Dossier de visite
09/01/00	PVM seat n° 2A replaced due damaged door
21/01/00	1°) Seat 1H PVM replaced due found door mechanism u/s tested satisfactory 2°) seat 2B PVM replaced due found cassettes door mechanism damaged. System tested satisfactory
27/01/00	Repair cargo panels (honey combs) fwd hold and aft hold. Repaired both holds (voir workcard n° 638)

ATA 28 (Carburant)

Date	Dossier de visite
22/01/00	Left inner and trim tanks R/D valves swapped for fuel spillage problem evaluation

ATA 32 (Train d'atterrissage)

Date	Dossier de visite
27/01/00	1°) ADD n° 12 : Tail skid paint [,,] Painted (Voir workcard n° 203), 2°) Component change report : ADD 15 actuator landing door left replaced OFF : S/N Tag missing, reason for removal, history not known ON : S/N K3523

ANNEXE 6
RETRANSCRIPTION DE LA BANDE D'ENREGISTREMENT DES
COMMUNICATIONS ENTRE LE CONTROLEUR ET L'EQUIPAGE DU VOL
KQ 431 DU 30 JANVIER 2000 SUR LA FREQUENCE 118,10 MHZ

HEURE	DE	A	CONVERSATIONS
20H55'23''	KQ 431	TWR	Tower good morning, Kenya Four-Three-One we now request start up for Lagos and stand by for the level
20H55'35''	TWR	KQ 431	Kenya Four-Three-One cleared to push and start for runway two-one, requesting the level is Three-Seven-Zero
20H55'59''	TWR	KQ 431	Copy report for taxi.
20H56'00''	KQ 431	TWR	Roger, we'll call for taxi.
21H01'10''	KQ 431	TWR	Tower Kenya Four-Three-One request taxi.
21H01'17''	TWR	KQ 431	Kenya Four-Three-One stand by for taxi.
21H01'19''	KQ 431	TWR	Standing by
21H01'45''	TWR	KQ 431	Kenya Four-Three-One taxi ah correction, give way to a Seven-Three-Seven of CAMAIR which is taxiing to Seven Bravo then taxiing, enter and back track Two-One via central taxiway. I'll call you back for ATC.
21H02'01''	KQ 431	TWR	Okay Kenya Four-Three-One to give way to the Boeing Seven-Three-Seven and then taxi, enter back track runway two-one, standing by for ATC.
21H02'45''	TWR	KQ 431	Kenya Four-Three-One report any time for ATC.
21H02'48''	KQ 431	TWR	Ah, you can go ahead Sir
21H02'56''	TWR	KQ 431	Kenya Four-Three-One you are cleared ABIDJAN to LAGOS via AFO, AFO clearance limit flight level two-tree-zero. Level change with ACCRA Centre.

HEURE	DE	A	CONVERSATIONS
21H03'10''	TWR	KQ 431	And left turn when airborne squawk five-zero-four-zero.
21H03'22''	KQ 431	TWR	And left turn when airborne, and to squawk five-zero-four-zero. Confirm the flight level ?
21H03'28''	TWR	KQ 431	The flight level is two-three-zero initially, two-three-zero initially.
21H03'32''	KQ 431	TWR	Two-three-zero initially, Sir.
21H07'35''	KQ 431	TWR	Kenya Four-Three-One ready for take-off.
21H07'40''	TWR	KQ 431	Kenya Four-Three-One cleared to take-off for runway two-one, wind two-four-zero degrees zero-four knots, report passing flight level four-zero.
21H07'47''	KQ 431	TWR	Cleared for take-off, runway two-one, we'll call you passing four-zero Kenya Four-Three-One
21H10'10''	TWR		... ABIDJAN
21H10'16''	TWR	SECURITE13	Sécurité 13 la Tour.
21H10'22''	SECU 13	TWR	Sécurité 13 à l'écoute.
21H10'28''	TWR	SECURITE13	Oui, il y a KENYA qui est tombé en mer là.
21H10'35''	SECU 13	TWR	Vous confirmez.
21H10'38''	TWR	SECURITE13	KENYA est tombé en mer.
21H10'42''	SECU 13	TWR	On vous entend très mal.
21H10'45''	TWR	SECURITE13	KENYA KENYA est tombé en mer, KENYA est tombé en mer.
21H10'50''	SECU 13	TWR	KENYA est tombé en mer, vous confirmez ?
21H10'55''	TWR	SECURITE13	Je confirme.
21H10'58''	SECU 13	TWR	Ok.
21H11'02''	TWR	KQ 431	KENYA 431 ABIDJAN

ANNEXE 7
TRANSCRIPTION DE L'ENREGISTREMENT CVR

Kenya Airways
Airbus A310-304, 5Y-BEN
Abidjan, Cote d'Ivoire (DIAP)
January 30, 2000

CVR TRANSCRIPT

Final Version: August 24, 2001

PROTECTED

Not to be Released without permission of the Agence Nationale De L'Aviation Civile (ANAC) of Cote d'Ivoire.

Prepared at:

Investigation Operations / Engineering
Transportation Safety Board Canada

A00F0009 LP011/00

FINAL VERSION

PROTECTED

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Abbreviations used in this transcript

P1	Captain - KQA431
P2	First Officer - KQA431
P1-PA	Captain making a public address.
P1-INT	Captain on the aircraft interphone system.
FA	Flight Attendant KQA431
FA-PA	Flight Attendant making a public address.
AC	Auto Callout
DIAP-TWR	Abidjan Tower
KQA-OPS	Kenya Airways Operations
Comment	Editorial comment
(.)	Word or words unintelligible
()	Questionable text
...	Pause
[]	Editorial comment
{ }	Translation to English. Original words spoken in Kiswahili
#	Expletive deleted
?	Unidentified speaker

WARNING

The transcription of a CVR, including the identification of speakers, is not a precise science but, is the result of a group investigative effort. The transcript, or parts thereof, if taken out of context, could be misleading.

NOTE

Only communications relating to the occurrence were transcribed.

The CAM channel had a strong 400hz signal on it which was used for time correction. The playback was originally done in order to achieve 400 Hz on playback. When the CVR was compared with the ATC times, it was determined that the CVR had to be increased in speed by 1.23%. This resulted in the ships inverter running at 404.9 Hz. The times in this transcript reflect a tape speed equivalent to 404.9 Hz.

FINAL VERSION**PROTECTED****DO NOT COPY**

SPEAKER	UTC	FLIGHT CREW CONVERSATIONS	RADIO COMMUNICATIONS
Comment		[Start]	
Comment	20:54:32.9	[CVR power up.]	
Comment	20:54:39.3	[Voices heard on flight deck-CAM very weak.]	
P1-INT	20:54:42.5	Ground.	
P1-INT	20:54:45.0	Ground.	
P2	20:54:52.9	Prepare for start.	
P1	20:54:53.9	Okay.	
P2	20:54:57.3	Prepare the crew.	
P1	20:54:58.2	Yeah.	
P2	20:55:22.0		Tower good evening Kenya Four-Three-One eh we now request start up forrr. Lagos... and ehh... stand by for the level.
P2	20:55:32.7	Unataka level gani? (What level do you want?)	
P1	20:55:34.1	Three-Five-zero... three-seven-zero.	
DIAP-TWR	20:55:35.1		Kenya Four-Three-One cleared to push and start for runway two-one, and... ah requesting the level is three-seven-zero.
P1	20:55:50.4	To Lagos one hour-fifteen minutes at ah... thirty-seven thousand.	
DIAP-TWR	20:55:58.3		Eh copied report eh... for taxi.
P2	20:56:02.0		Roger we'll call for taxi.
Comment	20:56:03.2	[Cockpit door closes.]	
P1	20:56:09.7	Checks.	
P2	20:56:13.1	Flight recorder.	
P1	20:56:14.5	Is on.	
P2	20:56:15.2	Beacon.	
P1	20:56:15.9	Is on.	
P2	20:56:16.5	Windows / doors.	
P1	20:56:17.4	They're all closed now.	
P2	20:56:18.7	Closed.	
P2	20:56:19.1	TRP?	
P1	20:56:19.8	(Flex sixty.)	
P2	20:56:21.4	Take off speeds?	
P1	20:56:22.6	I have uh one-sixty and pre-set two-fifty.	
P2	20:56:27.2	Ah parking brake.	
P1	20:56:29.3	Is still on.	
P2	20:56:30.7	Before start check complete.	
P1-INT	20:56:36.1	Ground!	
GM	20:56:38.0	Yes.	
P1-INT	20:56:39.9	We've been cleared to start and push, brakes are off.	
GM	20:56:44.8	Okay ***** push and startup. Okay runway two-one or zero-three.	
P1-INT	20:56:52.3	Runway two-one.	
GM	20:56:53.3	Okay, runway two-one.	
P1-INT	20:56:54.7	Can we start number two?	
GM	20:56:56.6	Eh standby.	
CAM	20:57:08.9	[Noise may be sound of tug pushing the aircraft.]	
GM	20:57:34.8	Ground, cockpit!	
P1-INT	20:57:36.1	Yeah!	
GM	20:57:37.0	Okay number two.	
P1-INT	20:57:38.4	Number two.	
P1	20:57:39.2	Start two.	
Comment	20:57:48.2	[single chime]	
Comment	20:57:49.9	[single chime]	
Comment	20:58:07.2	[single chime]	

FINAL VERSION
PROTECTED

SPEAKER	UTC	FLIGHT CREW CONVERSATIONS	RADIO COMMUNICATIONS
P1-INT	20:59:02.0	Number one.	
GM	20:59:03.2	Okay number one.	
P1	20:59:09.4	Number one.	
P2	20:59:14.1	Starting one.	
P1	20:59:16.5	Yeah.	
P2	20:59:18.7	Okay.	
GM	20:59:19.7	Push back completed, brake on please.	
P1-INT	20:59:22.6	Brakes are on.	
P7	20:59:25.3	[Cough]	
Comment	21:00:14.0	[Click on CAM and audio levels seem to increase.]	
P2	21:00:17.2	Oh!	
P1-INT	21:00:18.1	Okay, we have two normal starts, remove all ground equipment, signal to the left.	
Comment	21:00:20.2	[Cabin chime]	
GM	21:00:22.3	Okay, bye bye.	
P1-INT	21:00:24.1	Thank you.	
P2	21:00:30.6	Point nine nose up.	
Comment	21:00:34.7	[single chime]	
P2	21:00:43.2	Status... probe heat partially inop... Clear ECAM?	
P1	21:00:47.0	Clear.	
P2	21:00:49.8	Probe heat partially inop.	
P1-INT	21:00:53.9	Ground.	
P2	21:01:07.4		Tower Kenya Four-three-one ahh, request taxi.
DIAP-TWR	21:01:14.4		Kenya four-three-one standby for taxi.
P2	21:01:16.6		Standing by.
P2	21:01:33.7	Okay anti-ice is on off, status is checked, taxi check complete.	
P1	21:01:36.8	Thank you.	
P2	21:01:40.8	I think it's overheating, that's why it's failing. (please...) [cut off by ATC.]	
DIAP-TWR	21:01:43.0		Kenya Four-Three-One taxi ah correction give way to a Seven-Three-Seven of CAMAIR which is taxiing to Seven Bravo then taxiing enter and back track Two-One via central taxiway, I'll call you back for ATC.
P2	21:01:57.4		Okay Kenya Four-Three-One to give way to the Boeing Seven-Three-Seven and then taxi, enter back track runway two-one, standing by for ATC.
P1	21:02:21.3	Is that the centre taxiway?	
P2	21:02:23.0	Yeah.	
P1	21:02:33.3	Are you clear?	
P2	21:02:35.0	Clear.	
P1	21:02:37.0	Flaps to fifteen, fifteen.	
P2	21:02:38.9	Fifteen?	
P1	21:02:39.6	Fifteen.	
Comment	21:02:41.0	[Several sounds, possibly the flaps being set.]	
DIAP-TWR	21:02:44.3		Kenya Four-Three-One, ah report any time for ATC.
P2	21:02:48.3		Ah you can go ahead sir.
DIAP-TWR	21:02:50.5		Kenya Four-Three-One you are cleared Abidjan to Lagos via AFO, AFO clearance limit flight level two-three-zero. Level change with ACCRA Centre.
P2	21:03:01.5		Kenya Four-Three-One cleared Abidjan-Lagos ahhh AFO clearance limit flight level three-three-zero.
P1	21:03:09.2	Two-three-zero.	
DIAP-TWR	21:03:10.1		And ah left turn when airborne squawk five-zero-four-zero.
P2	21:03:16.7		Ah left turn ah when airborne, and to squawk five-zero-four-zero. Confirm the flight level?
DIAP-TWR	21:03:24.1		The flight level is two-three-zero initially, two-three-zero initially.

SPEAKER	UTC	FLIGHT CREW CONVERSATIONS	RADIO COMMUNICATIONS
P2	21:03:28.7		Two-three-zero initially sir.
P1	21:03:32.1	Turning...right, skidding to the...left?	
P2	21:03:35.5	Skidding left.	
P1	21:03:37.5	Zero-seven-zero...request further taxi.	
P2	21:03:41.1	We are cleared to enter and back track.	
P1	21:03:42.5	We are cleared to enter and back track?	
P2	21:03:43.6	Yeah.	
P1	21:03:44.0	Three times.	
P2	21:03:45.6	Checks, horizon steady, VOR tracking...zero-four-zero.	
P1	21:03:50.1	Clear?	
P2	21:03:50.9	Five-zero-four-zero.	
P1	21:03:52.7	Clear?	
P2	21:03:53.5	Ah, right is clear.	
P1	21:04:08.8	Turning left.	
P2	21:04:08.1	Yeah skidding right.	
P1	21:04:08.8	To the right.	
P1	21:04:14.4	Zero-seven-zero again.	
P1	21:04:16.5	Three times.	
P2	21:04:17.2	*** checks, horizon steady, VOR tracking and ADF's.	
P1	21:04:22.6	Flight controls?	
P2	21:04:29.8	Nose down.	
Comment	21:04:33.4	[Unidentified sound]	
P2	21:04:36.0	Ailerons central...aileron checked. Rudder.	
P2	21:04:42.2	Full left.	
P2	21:04:44.8	Neutral.	
P2	21:04:46.9	Full right.	
P1	21:04:48.8	Take-off checks.	
P2	21:04:50.6	Take-off checks...trims...ah zero, zero, point nine nose up...slats/flaps fifteen/fifteen we have, ahhhhh...controls.	
P1	21:05:02.4	Checked.	
P2	21:05:02.9	Checks, take-off configuration...normal for take-off.	
P2	21:05:07.8	Packs...on engines...instruments?	
P1	21:05:12.6	I have zero...zero-three-zero three times, normal flags.	
P2	21:05:17.5	Normal flags, down to the line.	
?	21:06:18.4	***** [Very faint voice.]	
P1	21:06:17.7	Thank you. [Possibly in response to the purser.]	
P1	21:06:49.3	Final checks?	
P1-PA	21:07:09.9	Ah.. Good evening again ladies and gentlemen, we'll be taking off shortly, ***	
P2	21:07:17.2	Take-off PA is done, radar is on, transponder code set on, autobrake maximum, ignition continuous reight, take-off checks complete.	
P2	21:07:32.3		Kenya Four-Three-One ready for take-off.
DIAP-TWR	21:07:35.8		Kenya Four-Three-One cleared to take off for runway two-one, wind two-four-zero degrees ah zero-four knots, report passing flight level four-zero.
P2	21:07:45.6		Cleared for take off runway two-one, we'll call you passing ah four-zero, Kenya Four-Three-One.
P1	21:08:06.9	Final checks complete?	
P2	21:08:08.0	Final checks complete...cleared for take off.	
P2	21:08:11.8	Oh, two-five point... [Interrupted by P1.]	
P1	21:08:13.4	Stopwatch?	
P2	21:08:15.9	Yeah.	
Comment	21:08:18.1	[Start of engine spool up.]	

SPEAKER	UTC	FLIGHT CREW CONVERSATIONS	RADIO COMMUNICATIONS
1	21:08:18.4	Thrust SRS and runway	
2	21:08:20.8	Checks.	
Comment	21:08:21.9	[CAM level increases significantly; intermittently at first]	
2	21:08:28.7	(Speed *)	
1	21:08:29.0	Take off power is set. [P2 is the pilot flying.]	
2	21:08:30.4	Okay.	
1	21:08:37.1	One hundred knots.	
2	21:08:37.8	Checks.	
1	21:08:50.7	V one and rotate.	
Comment	21:08:55.1	[Mechanical sound consistent with normal nose gear extension]	
Comment	21:08:56.1	[Two click sounds consistent with trim switch]	
1	21:08:56.7	Positive.	
Comment	21:08:57.2	[Two click sounds consistent with trim switch]	
2	21:08:57.4	Positive rate of climb; gear up.	
Comment	21:08:59.1	[Start of audible Stall Warning]	
Comment	21:09:00.4	[Unidentified noise for approximately two seconds]	
1	21:09:03.7	Uh-hoo [exclamation/surprise/stress]	
C	21:09:07.8	Three hundred.	
2	21:09:10.9	Ahhh?	
2	21:09:14.0	What's the problem?	
C	21:09:15.8	Two hundred.	
Comment	21:09:16.1	[Amplitude of CAM reduces for 0.2 seconds - possible physical tape damage]	
2	21:09:18.5	Silence the horn.	
C	21:09:19.3	One hundred.	
Comment	21:09:20.3	[End of audible Stall Warning]	
Comment	21:09:20.9	[Blip sound, consistent with first 50 milliseconds of a "Whoop..." from GPWS]	
C	21:09:21.4	Fifty.	
C	21:09:22.1	(For... [possibly truncating forty])	
C	21:09:22.5	Thir... [possibly truncating thirty] Twenty... Ten.	
Comment	21:09:22.5	[Start of continuous repetitive chime - Master Warning]	
1	21:09:22.9	Go up!	
Comment	21:09:23.9	[End of continuous repetitive chime - Master Warning]	
Comment	21:09:24.0	[First sound of impact]	
Comment	21:09:27.6	[End of Recording]	

ANNEXE 8

CARTOGRAPHIE DU PLAN DE REPARTITION DES DEBRIS

ANNEXE 9
PHOTOGRAPHIE DE QUELQUES DEBRIS RECUPERES EN SURFACE ET
SUR LA PLAGE OU OBSERVES SOUS LA MER



Dérive



Train d'atterrissage repêché



Amortisseur du train d'atterrissage



Vis de vérin de volets



Vis de vérin du plan horizontal réglable



Moteur



Console centrale du cockpit

ANNEXE 10
RESULTATS D'ANALYSES DE CARBURANT



SGS Redwood Services
A Division of SGS Côte d'Ivoire S.A.

Km 1 Boulevard de Marseille
01 BP 705
Abidjan 01

Fax: +225 25 59 14
Tel: +225 24 00 42
Telex: 42164 REDW CI

Client: SHELL COTE D'IVOIRE

Vessel:

Cargo: JET A-1

Port: ABIDJAN

Installation: HES Port Bouet

Report No: CID00061/C/ANALYABU-16

Analytical Report

Issue 17 - October 1996, Supersedes Issue 16 - June 1996

At Loading

Test ID: 0154/2000

Sample Identification: 2 x 2 litre plastic can

Sample Source: Filter Server 38

Drawn by: SGS Redwood

Time: 11.00 hrs

Analysis carried out by: SGS Redwood

Time: 23.55 hrs

Date: 31 Janvier 2000

In: our Abidjan Laboratory

Date: 31 Janvier 2000

grade shown:

a) British MoD DEF STAN 91-91 Issue 2 dated 8th May 1986, plus all amendments up to 3 dated 11 September 1998, Jet A-1
b) ASTM D 1655 - 97, Jet A-1
c) IATA Guidance Material for Aviation Turbine Fuels, 3rd Edition, March 1999, Kerosene Type Fuel

PROPERTY	Remarks	TEST METHOD	RESULT	LIMITS
APPEARANCE		Visual	Clear and Bright	Clear, bright and visually free from solid matter and undissolved water at normal ambient temperature
COMPOSITION	(see 1)			
Total Acidity, mgKOH/g		ASTM D 3242	0.003	0.015 max
Aromatics, % vol		ASTM D 1319	17.6	22.0 max
Sulfur total, % mass		ASTM D 4294	<0.05	0.30 max
Ductor Test	(see 2)	IP 30	Negative	Negative
Hydroprocessed fuel in batch, % vol	(see 3)			Report (include "nil" or "0%")
VOLATILITY				
Distillation		ASTM D 86		
- Initial Boiling Point, °C			162.0	Report
- 10% vol recovered, °C			182.0	205 max
- 20% vol recovered, °C			189.0	Report
- 50% vol recovered, °C			311.0	Report
- 90% vol recovered, °C			248.0	Report
- End Point, °C			263.0	300 max
- Residue, % vol			1.0	1.5 max
- Loss, % vol			1.0	1.5 max
Flash Point, °C	(see 4)	ASTM D 3828	51	38 min
Density at 15°C, kg/m³		ASTM D 4052	828.6	775 - 840
FLUIDITY				
Freezing Point, °C	(see 5)	ASTM D 2386	-51.0	minus 47 max
Viscosity at -20°C, cSt (mm²/s)		ASTM D 445	4.892	8.0 max
COMBUSTION				
Specific Energy, net, MJ/kg	(see 6)	ASTM D 4829	42.95	42.8 min
Smoke Point, mm		ASTM D 1322	20.3	19 min
AND Naphthalenes, % vol		ASTM D 1840	1.74	3.0 max
CORROSION				
Copper Corrosion (2h at 100°C)		ASTM D 130	1a	1 max
Silver Corrosion (4h at 50°C)		IP 227	0	2 max
STABILITY				
Thermal Stability (JFTOT) Control Temp. 260°C		ASTM D 3241		
- Filter Pressure Differential, mmHg			2.4	25.0 max
- Tube Deposit Rating (Visual)			0	Less than 3 max, or "Peculiar" or "Abnormal" colour deposits
CONTAMINANTS				
Existent Gum, mg/100 cm³		ASTM D 381	1	7 max
Water Reaction Interface Rating		ASTM D 1094	1b	1b max
Microseparometer (MSEP), ratings	(see 7)	ASTM D 3948		
- Fuel with Static Dissipator Additive			90	70 min
- Fuel without Static Dissipator Additive				85 min
CONDUCTIVITY				
Electrical Conductivity, pS/m (T°C= 26)	(see 8)	ASTM D 2624	291	50 - 450
ADDITIVES (Only those approved in DEF STAN 91-91-2 are Antioxydant), mg/l				
- in Hydroprocessed Fuels (Mandatory)	(see 9)			17.0 - 24.0
- in Non-hydroprocessed Fuels (Optional)				24.0 max
Metal Deactivator, mg/l (Optional)	(see 10)			5.7 max
Static Dissipator, mg/l (Mandatory)				3.0 min
- First Doping Studix 430				
- Re-doping	(see 11)			

CERTIFICATE OF ANALYSIS
CERTIFICAT D'ANALYSE

Aviation Fuel Quality Requirements for Jointly Operated Systems

AFQRJOS ISSUE 17 - check List Jet A-1 (October 1998)

Embodying the most stringent requirements of the three following specifications:

Incorporant les exigences les plus strictes des trois spécifications suivantes:

(a) British Ministry of Defence Standard, DEF STAN 91-91/Issue 2 (DERD 2494), dated 8 May 1996 (plus all amendments up to Amendment 3 dated 11/9/98), Jet A-1.

(b) ASTM D1655-97, Jet A-1.

(c) IATA Guidance Material for Aviation Turbine Fuels, 3rd Edition (part 1), dated March 1998 for "kerosine Type Fuel".

() See remarks on the reverse side - () Voir les commentaires au verso

RAFFINERIE/LABORATOIRE

REFINERY/LABORATORY

SOCIÉTÉ IVOIRIENNE DE RAFFINAGE

01 BP 1269 ABIDJAN 01

Jet A-1

TEST CERTIFICATE n°

CERTIFICAT D'ANALYSE N°

BATCH n°

LOT n°

Sample n° TOTAL CI AEROPORT

Echantillon n° 200147561

TANK n° FILTRE 38

BAC n°

Sampling Date 01/02/00

Date d'échantillonnage

Methods	Méthodes	Properties	Caractéristiques	Results	Résultats	Limits	Limites
Visual	Visuelle	APPEARANCE	ASPECT		CLAIR/LIMPE	Clean and Bright	Clair et Limpide
ASTM IP		COMPOSITION (1)	COMPOSITION (1)			(sans eau non dissoute, ni sédiments à l'ambient)	
D3242	354	Total Acidity	Acidité Totale	mg KOH/g	0.0012	0.015 max.	
D1319	155	Aromatics	Aromatiques	% vol.	17.6	22.0 max.	
D1319	155	OR Aromatics	OU Aromatiques	% vol.		25.0 max.	
D3701	339	AND Hydrogen content	ET Teneur en Hydrogène	% mass.		Report	
or D3343							
D1266	107	Sulfur, Total	Soufre Total	% mass.	0.05	0.30 max.	
or D2623							
or D4294							
or D1552							
D3227	342	Sulfur, Mercaptans	Soufre Mercaptan	% mass.		0.0030 max.	
52	30	OR Doctor Test (2)	OU Doctor Test (2)		NEGATIF	Négatif	
		Hydrogenated Fuel in batch (3)	% Hydrogéné (3)	% vol.	0	Report (incl. "nil" or "100 %")	
D66	123	VOLATILITY	VOLATILITE				
D66	123	Distillation Initial Boiling Point	Point Initial	°C	168.8	Report	
D66	123	10 % vol. rec.	10 % vol. rec.	°C	181.6	205 max.	
D66	123	50 % vol. rec.	50 % vol. rec.	°C	208.7	Report	
D66	123	90 % vol. rec.	90 % vol. rec.	°C	244.8	Report	
D66	123	End Point	Point Final	°C	259.8	300 max.	
D66	123	Residue	Résidu	% vol.	1.3	1.5 max.	
D66	123	Loss	Perte	% vol.	1.0	1.5 max.	
D3808	170 or 303	Flash Point	Point d'Éclair	°C	50.0	38 min.	
D3808	170 or 303	OR Flash Point (4)	OU Point d'Éclair (4)	°C		40 min.	
D154	160	Density at 15° C	Masse volumique à 15° C	kg/m3	827.6	775 - 840	
or D4002	or 385						
D2596	16	FLUIDITY	FLUIDITE				
or 590		Freezing Point	Point de disparition de cristaux	°C	-49.0	minus 47 max.	
or 4205 (5)							
or 5973							
D445	71	Viscosity at -20° C	Viscosité à -20° C	mm2/s (cSt)	5.532	8.0 max.	
D669		COMBUSTION	COMBUSTION				
or D3536 (6)		Specific Energy, net	Pouvoir calorifique inf.	MJ/kg	43.0	42.8 min.	
or D5729 (6)	361 (6)						
D1222		Smoke Point	Point de fumée	mm		25 min.	
or 140		OR Luminometer Number	CU Ind. Luminomètre			45 min.	
or 140		OR Smoke Point	OU Point de fumée	mm	21	19 min.	
or 140		AND Naphthalenes	ET Naphthalènes	% vol.	1.78	3.0 max.	
D153	454	CORROSION	CORROSION				
227		Corrosion, Copper (2h at 100° C)	Corrosion Cuivre	Classification	1A	1 max.	
		Corrosion, Silver (2h at 50° C)	Corrosion Argent	Classification	0	2 max.	
D3441	323	THERMAL STABILITY (260° C)	STABILITE THERMIQUE (260° C)				
D3241	323	JETOT Filter Pressure Differential	Delta P du Filtre	mmHg	5.4	25.0 max.	
		Tube Depositing Rating (Visual)	Corrosion Tube (Visuelle)		0	< 3 max.	
		no "Pecorack" or "Abnormal" color deposits	sans viscosité ou dépôt anormalement colorés				
D381	131	CONTAMINANTS	CONTAMINANTS				
D1094	289	Existent Gum	Sommes Actuelles	mg/100 cm3	0	7 max.	
D5946		Water Reaction Interface Rating	Décoloration Interface		1B	1B max.	
		Microseparator (MSEP), ratings					
		Fuel with Static Dissipator Additive (7)	Carburant additivé (7)		96	70 min.	
		Fuel without Static Dissipator Additive	Carburant non additivé			65 min.	
D2624	274	CONDUCTIVITY	CONDUCTIVITE				
Brand	Marque	Electrical conductivity (8)	Conductivité électrique (8)	pS/m	324	50 - 450	
		ADDITIVES (A) (B) (C) (D)	ADDITIFS (A) (B) (C) (D)				
		Antioxidant in Hydroprocessed & synthetic Fuels (mandatory) (9)	Antioxydant dans produit hydrotraité et de synthèse (obligatoire) (9)	mg/l	0.0	17.0 - 24.0	
		Antioxidant in non Hydroprocessed Fuels (optional)	Antioxydant (proc. non hydrotraité) (optionnel)	mg/l		24.0 max.	
		Metal Deactivator (optional) (10)	Désactivant (optionnel) (10)	mg/l		5.7 max.	
STADIS	450	Static Dissipator Additive (SDA)	Additif anti-statique				
		First doping STADIS 450	Tère additivation STADIS 450	mg/l	0.0		
		Redoping (11)	Re-additivation (11)				

Société Ivoirienne de Raffinage
Laboratoire d'Analyses

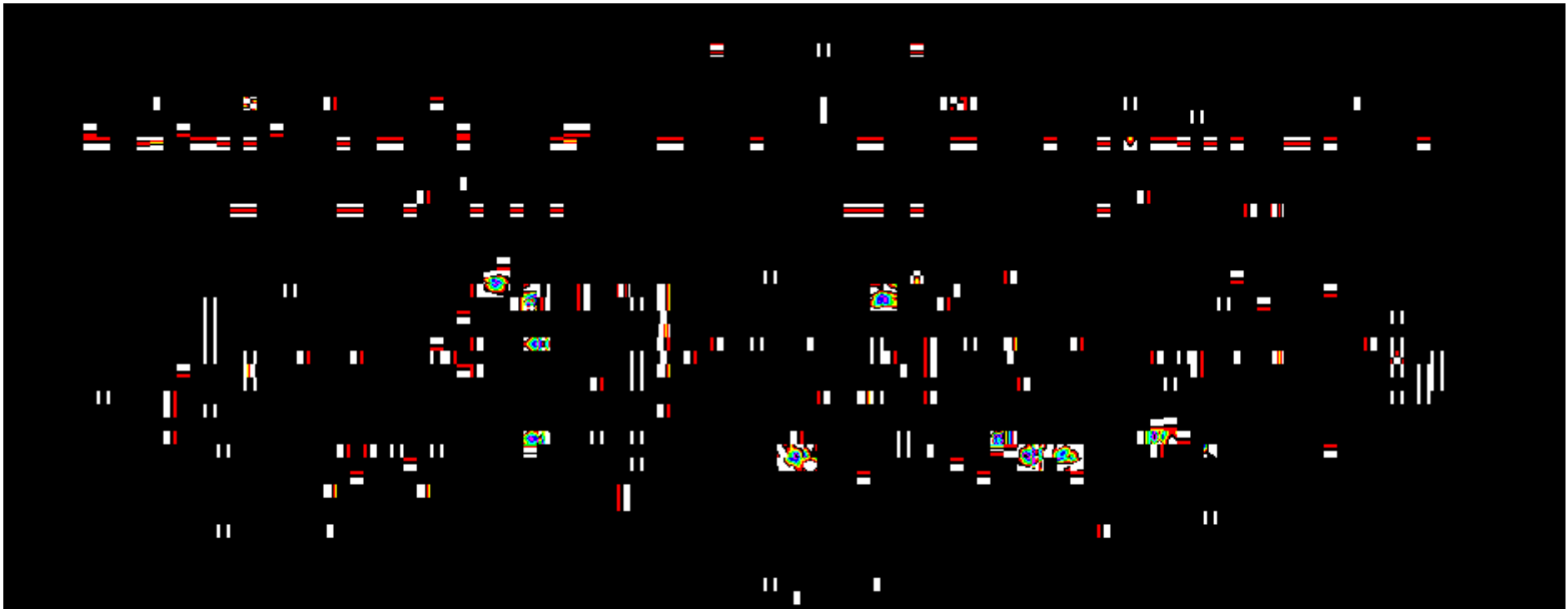
The chief chemist certifies that the product complies with the specifications detailed above.
Le chef de laboratoire certifie que le produit est conforme aux spécifications détaillées ci-dessus.

DATE 01/02/00
SIGNATURE

Le Chef

ANNEXE 11
PLAN D'OCCUPATION DES SIEGES DES RESCAPES

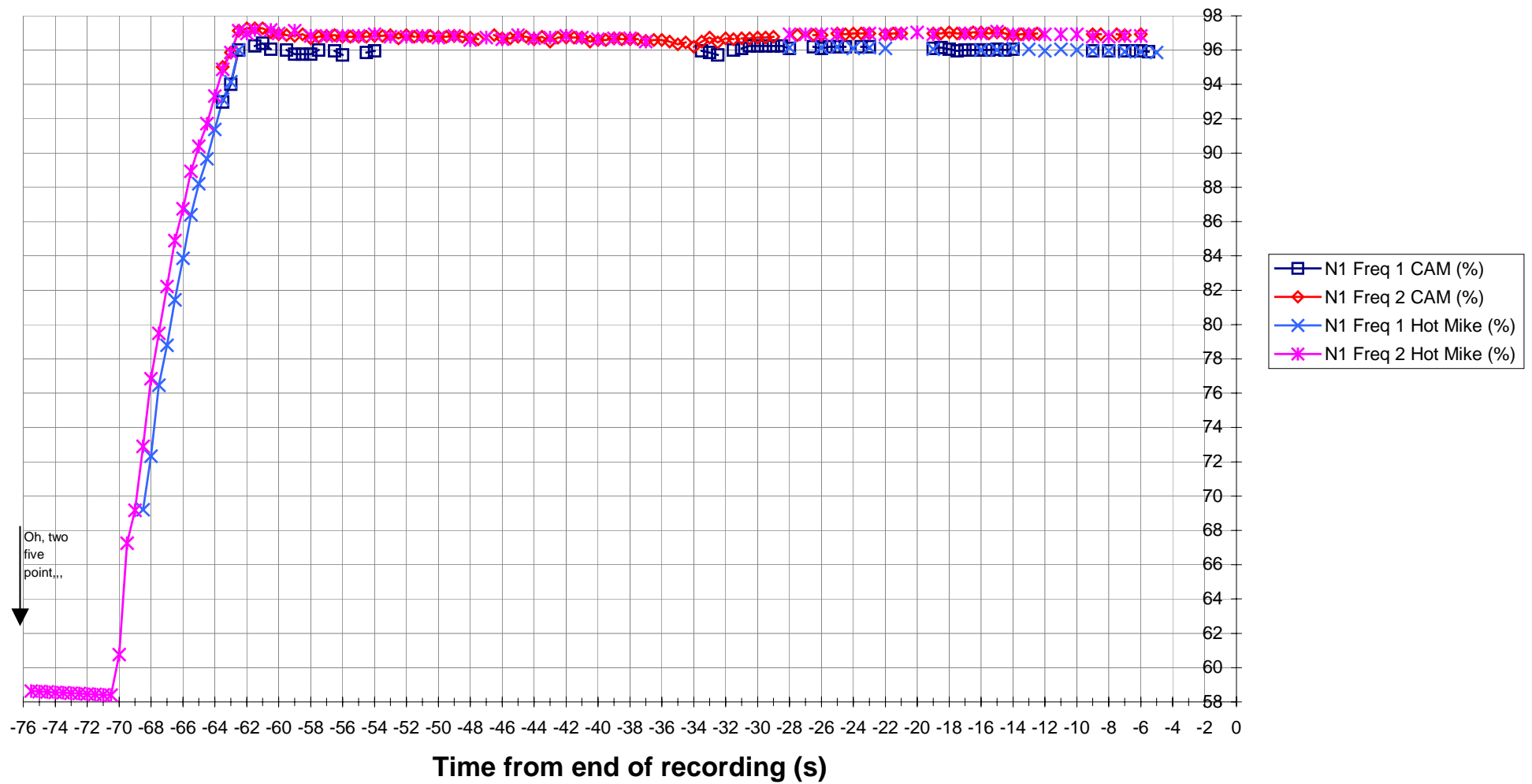
v Survivants



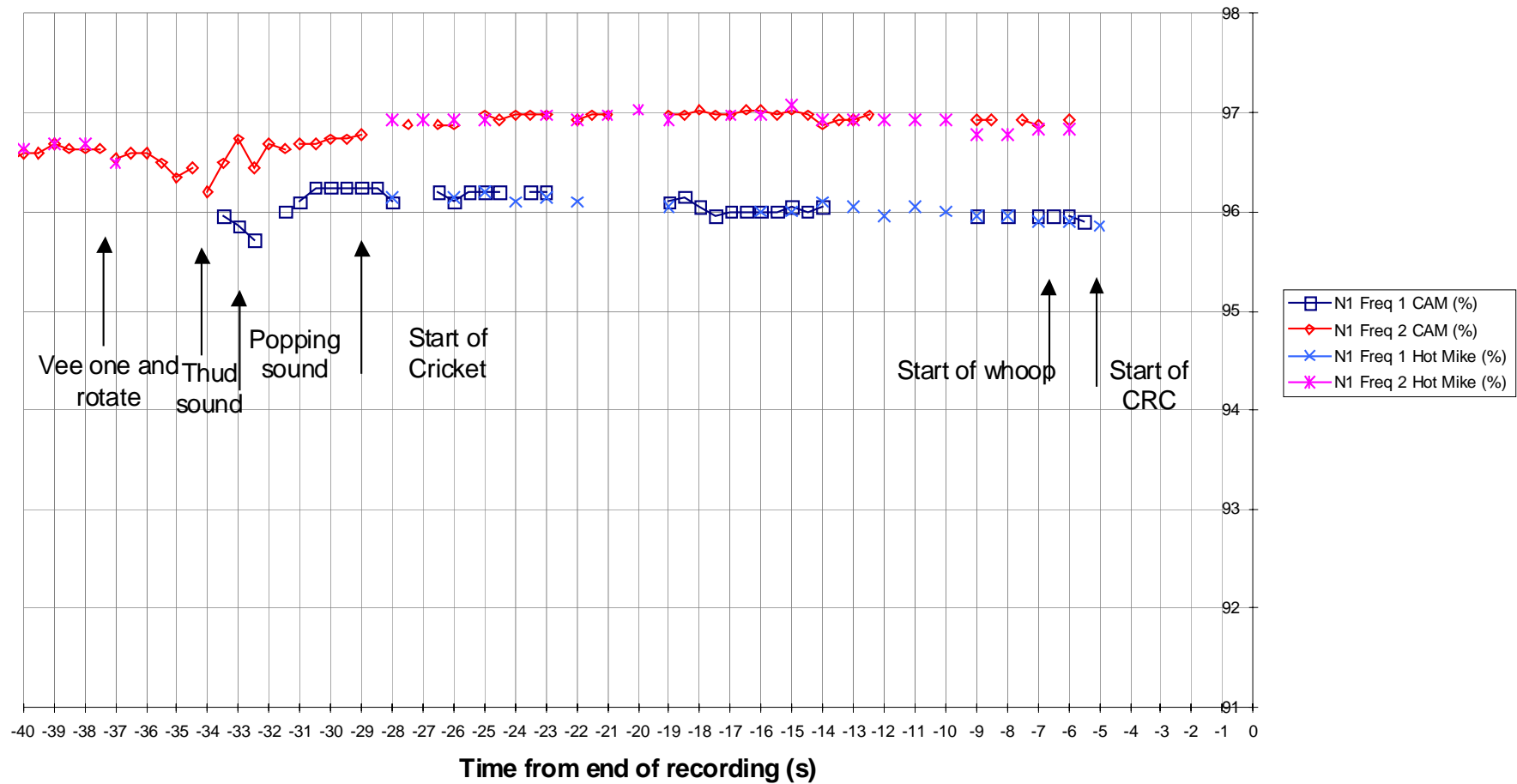
ANNEXE 12

COURBES ISSUES DE L'ANALYSE SPECTRALE DES MOTEURS

5Y-BEN CVR Spectral Analysis



5Y-BEN CVR Spectral Analysis



ANNEXE 13
RAPPORT CONCERNANT LE FDR

FLIGHT RECORDERS ANALYSIS
LP011/00

Airbus A310-304, SY-BEN
Abidjan, Cote d'Ivoire
January 30, 2000

This report was prepared exclusively for the Agence Nationale De L'Aviation Civile (ANAC) of Cote d'Ivoire.

At the request of the Agence Nationale De L'Aviation Civile (ANAC) of Cote d'Ivoire, the Transportation Safety Board of Canada (TSB) analyzed the Flight Recorders in order to assist in the investigation. The TSB Flight Recorder Group consisted of the following persons:



Michael R. Poole, P. Eng.
Manager, Recorder Analysis & Performance
Accredited Representative
TSB/Canada
(State of Recorder Readout)



Date

Peter Kramar, P. Eng.
Senior Aerospace Engineer
TSB/Canada

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Dennis Pharoah
Recorder Analyst
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APPENDIX A - *Parameter List*APPENDIX B - *CVR Transcript*APPENDIX C - *Figures*APPENDIX D - *Glossary*

1.0 INTRODUCTION

On January 30, 2000, at approximately 21:10 UTC, a Kenya Airways Airbus A310-304, registration 5Y-BEN, designated *KQ431*, impacted the Atlantic Ocean immediately after take-off, approximately 1.2 km from the Felix Houphouet-Boigny Airport, Abidjan, Cote d'Ivoire. Of the 179 persons on board, 169 persons were fatally injured. The aircraft's flight recorders were recovered from the wreckage in approximately 55 meters of water. Authorities from Cote d'Ivoire requested assistance from the Transportation Safety Board of Canada (TSB) with respect to analyzing the recorders. On February 23, 2000, the recorders arrived at the TSB's Engineering Branch laboratory facilities in Ottawa, Ontario, Canada, hand carried in water by representatives from Cote d'Ivoire.

This report has been prepared exclusively for the Agence Nationale De L'Aviation Civile (ANAC).

2.0 RECORDER INFORMATION

2.1 DFDR Readout

The DFDR was a Honeywell (formerly Allied Signal/Sundstrand) flight data recorder, model UFDR 980-4100-DXUN, serial number 7172. This FDR records 25 hours of digital flight data on an eight track 1/4 inch tape medium. The parameter list for this aircraft is documented in Appendix 'A' of this report. It was last played back by Allied Signal Aerospace Toulouse on 5/9/97, without apparent problems.

The recorder was transported in water to minimize oxidation. It was found to exhibit slight impact damage to the outer casing and face plate (Figure 1). The recorder was rinsed with fresh water and disassembled in order to remove the tape medium. The internal crash protected memory module and the tape medium were found to be in pristine condition (Figures 2 and 3). There was no corrosion damage to the recording.



Figure 1: FDR as received

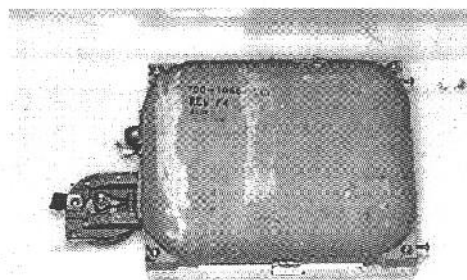


Figure 2: Memory module

Decoding of the recorder revealed that tracks 1, 2, 4, 6 and 8 contained a steady stream of digital 'zeros', with occasional steady streams of digital 'ones'. Tracks 3 and 7 contained only digital 'zeros' and track 5 contained only digital 'ones'. No synchronization codes nor valid data were found, which typically consists of an alternating pattern of 'ones' and 'zeros'.

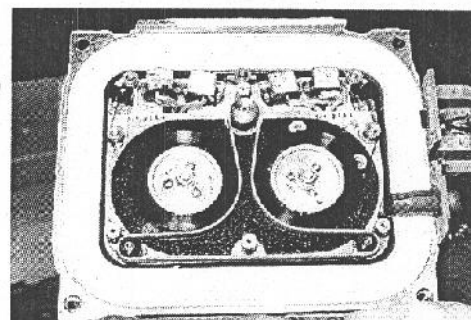


Figure 3: Tape medium

Figure 4 depicts the relative percentage of blocks of 'ones' and/or 'zeros' on each of the eight tape tracks. It should be noted that for odd tracks (1, 3, 5, 7), the recording proceeds from left to right (i.e. forward). For even tracks (2, 4, 6, 8), the recording proceeds from right to left (i.e. reverse). Data is recorded onto each track in sequence, starting on track 1 in the forward direction. At the end of track 1, the recording switches to track 2 and records in the reverse direction. At the end of track 8, after approximately 25 hours of data is recorded, the recording switches back to track 1 and the process repeats, overwriting the previous data. A large section of 'ones' was found, starting near the 2/3 point of reverse track 4, continuing for the entire forward track 5, and then changing to 'zeros' about 1/3 into reverse track 6.

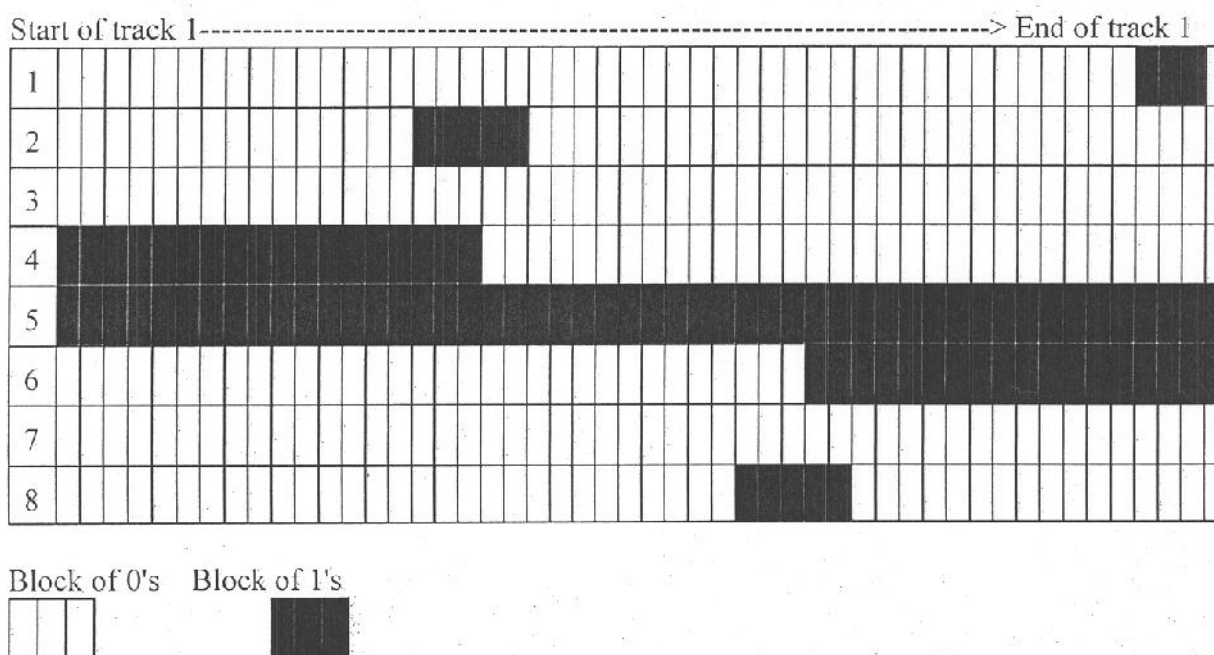


Figure 4: Percentage of tape that contained blocks of 'ones' and/or 'zeros'

The sample patterns of 'ones' and 'zeros' represented by the Harvard Bi-Phase signal, are

depicted in Figures 5 and 6, respectively.

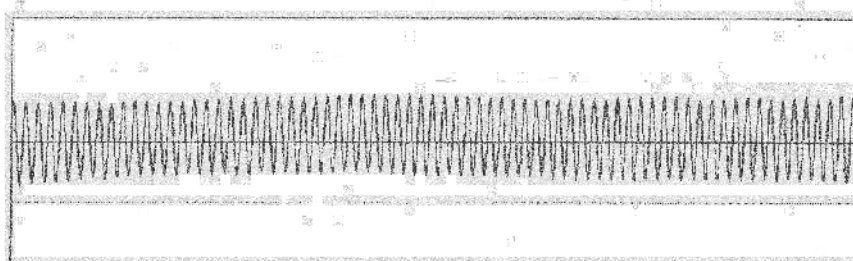


Figure 5: Sample pattern of 'ones' from accident FDR

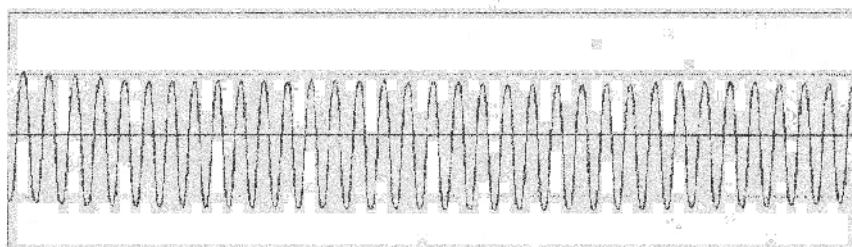


Figure 6: Sample pattern of 'zeros' from accident FDR

2.2 CVR Readout

The Cockpit Voiced Recorder (CVR) was an L3 Communications (formerly Loral) model A100, serial number 2493. The CVR recorded the last approximately 31 minutes of audio on a four track 1/4 inch tape capturing the accident, including the engine start, taxi and take-off up to the point of impact with the water.

The recorder was transported in water to minimize oxidation. Some impact damage was observed to the outer casing and face plate (Figure 7). The recorder was rinsed with fresh water and disassembled in order to remove the CVR tape. The tape medium was found to be in pristine condition with no corrosion damage. The tape was originally played back on an open reel tape deck at the normal speed of 1 7/8 inches per second using 400 hz AC power. A comparison of the CVR communications with the identical communications recorded on the ATS tape indicated that the original playback speed was too slow, requiring a 1.23% increase in speed. This was considered due to a slight difference between the playback speed

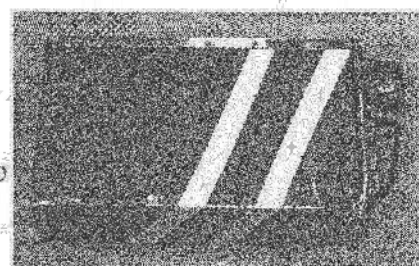


Figure 7: CVR as received

using TSB's hardware and the CVR recording speed.

A CVR audition group was established to transcribe the recording and consisted of members of the TSB, Cote d'Ivoire ANAC, and representatives of the Kenya DCA (Directorate of Civil Aviation) and Kenya Airways. The quality of the recording was very good, as hot mics were used. Most of the internal cockpit and all radio communications were in the English language. Some internal cockpit communications which were in the Kiswahili language, were transcribed into the English language with the assistance of the Kenyan representatives. A partial transcript was initially provided to the Cote d'Ivoire authorities and to the Bureau Enquete Accident (BEA) for further study. Additional refinements were subsequently made to the transcript and the final version is included in Appendix B.

3.0 DATA RECORDER SYSTEM DESCRIPTION

3.1 *Digital Flight Data Recorder*

According to the DFDR manufacturer, if the recorder does not receive 768 bits (one second of data) within the allotted one second time frame, the contents of the received buffer is written to the tape. The buffer could be an empty (all zeros) or partially empty buffer.

3.2 *Digital Flight Data Acquisition Unit*

The Digital Flight Data Acquisition Unit (DFDAU) was a SFIM Industries model 360-42600-050. The DFDAU was not recovered from the wreckage on the sea bed.

3.3 *Flight Recorder System Fault Indication and Monitoring*

The DFDR was taken to the manufacturer (Honeywell) for bench testing to determine what conditions or faults, if any, may have occurred to result in the stream of erroneous data. A test protocol was developed where by the components from the accident recorder were substituted one by one into a bench unit. The results suggested that the DFDR was probably serviceable, as the failure of the cards during bench testing was likely due to impact damage.

The A310 BITE configuration was reviewed to determine why the crew did not realize that the flight recording system was not functioning properly during pre-flight checks. To check for correct functioning of the flight recorder system, the DFDAU and DFDR are each monitored by their respective BITE systems. The DFDAU BITE monitors numerous operations, including the input/output functions, memory, microprocessor and DFDR playback signal operations. The DFDR BITE monitors tape motion, input data stream, recorded data and power supply circuitry operations. When a failure is detected, the monitoring system illuminates the respective cockpit indication lights on the FLT RCDR Control Panel. When the DFDAU fails, the DFDAU BITE

output activates the yellow DFDAU indicator light on the control panel. When the DFDR fails, the DFDR status output activates the yellow DFDR indicator light, except when the DFDAU indicator is also activated. The status of both units are also indicated on the front side of the DFDAU by two separate indicators. For example, in the case of a DFDR hardware fault or when no input to the DFDR is detected and there is no associated DFDAU BITE output, the DFDR status output activates the DFDR indicator light (Appendix C, Figures 8 and 9). In the case of a DFDAU hardware fault, the DFDAU BITE output activates the DFDAU indicator light, however, the DFDR status output is inhibited from activating the DFDR indicator light (Appendix C, Figure 10). On the accident flight, as the flight crew actioned the Before Start checklist, the flight recorder was indicated as 'ON'. Pressing the GND/CTL button on the FLT RCDR Control Panel normally illuminates the blue ON button, energizing the DFDR and turning off the yellow DFDR indicator light if no failures are detected. There were no indications from the crew that a problem existed with the flight recording system during the pre-flight checks. No anomalies were found with the DFDR which suggested a pre-impact problem. Since the DFDR appears to have been functioning properly and the nature of the recorded static data suggests a DFDAU problem, it is probable that the DFDAU light was illuminated and the DFDR light was off (inhibited). The checklist only makes reference to the flight recorder with no reference to a DFDAU, so it is possible that the yellow illumination of the DFDAU did not cause the crew concern. It is also possible that the DFDAU light may have been burned out.

4.0 CVR FACTUAL SEQUENCE OF EVENTS

The CVR recording began as the flight was cleared by Abidjan Tower for push back and engine start, with Runway 21 identified as the departure runway. The Before Start checklist was completed, including reference to the flight recorder being 'On' and with take-off speeds of 160 KIAS and 250 KIAS indicated. The engine start sequence was considered normal, and pitch trim was set to point nine nose-up. The Taxi checks were then carried out, including a status check, which revealed that the probe heat was partially inoperative. The copilot perceived the probe heat anomaly to be related to an overheating problem. The ECAM was also indicated to be clear.

The flight was cleared to taxi, to enter and backtrack Runway 21. During this time, the captain called for flaps set to 15 degrees and sounds were recorded, possibly that of the flap lever moving. Abidjan Tower cleared the flight to Lagos at a flight level of 230, with a left turn after take-off. Instrument and flight control checks were carried out without apparent problems. The Take-Off checklist items were called out, which included trims set to zero, zero and point nine nose-up, slats/flaps set to 15/15, the take-off configuration was normal for take-off and normal flags were indicated. Final checks included the ignition set to continuous relight. The take-off clearance included a wind check of 240 degrees at four knots.

The start of the take-off was apparent from the engine spool-up sounds recorded from 21:08:18.L. From voice identification, it was determined that the copilot was the pilot flying.

Take-off power was set approximately 10.9 seconds after engine spool-up, as called out by the captain. The 100 knot call out was made by the captain approximately 19 seconds into the take-off roll. This was followed by the captain's V, and rotate call, 32.6 seconds into the take-off roll. A mechanical sound was recorded on the CAM channel approximately 4.4 seconds after the rotate call, which was consistent with normal nose gear extension during rotation. Sounds consistent with the normal movement of the trim rocker switch were also recorded. The captain uttered the word 'positive' six seconds after the rotate command and 0.7 seconds later, the copilot acknowledged a positive rate of climb and requested the gear up. Within 1.7 seconds of the gear up request (24.9 seconds before impact), a warning horn activated, identified as the stall warn horn, which continued to sound for the next 21.2 seconds. Numerous decreasing auto altitude call outs were recorded starting with a 300 foot call, 17.1 seconds after the rotate command (16.2 seconds before impact). The auto call outs, based on radio height in feet AGL, indicated a descending profile, with the final call out of 10 feet recorded within a second of impact. Within 6.2 seconds after the 300 foot call out (10 seconds before impact), as the stall warning continued, the copilot queried the captain as to what the problem was and requested that the horn be silenced. The stall warning horn stopped about 1.8 seconds later (3.7 seconds before impact), between the 100 and 50 foot call outs. Approximately 30.2 seconds after the rotation command (3.1 seconds before impact), a sound approximately 50 milliseconds in duration was recorded, which was consistent with a brief fragment of the 'Whoop' from the GPWS, according to the BEA. A continuous repetitive chime began to sound approximately 1.6 seconds later, consistent with activation of the Master Warning. Approximately 1.1 seconds prior to impact, the captain urgently commanded the copilot to climb.

5.0 CVR SPECTRAL ANALYSIS AND ALTITUDE CALL-OUTS VS TIME

A spectral analysis of the CAM channel for the accident take-off showed the spool-up of both engines to thrust levels which were consistent with take-off thrust (Appendix C, Figure 11). The engine signatures indicated that both engines were matched at the take-off thrust setting during the initial portion of the take-off roll. A slight divergence in thrust was noted after rotation, however, both engines appeared to continue at high thrust levels up to the time of impact. The signature of the stall warning horn, at approximately 1,600 hz, can be seen at the bottom right corner of the figure.

The auto altitude call outs recorded during the final 16 seconds of the take-off were plotted as a function of time from the start of engine spool-up (Appendix C, Figure 12). A mathematical smoothing algorithm was applied to the data, which was then differentiated to provide an indication of the vertical rate of climb. The CVR recording indicated that there was a change from a positive to a negative rate of climb at some point following the stall warning activation. The derived vertical rate suggests that the rate of descent exceeded 1,000 feet/min, and that a recovery was possibly initiated, as suggested by an apparent reduction in the rate of descent, during the final 10 seconds of the flight.

6.0 SUMMARY

This report is limited to the work that was carried out for the Cote d'Ivoire authorities in support of the flight recorder playback and analysis.

APPENDIX A

FDR Parameter List

Kenya Airways Airbus A310-304 Accident
5Y-BEN
Abidjan, Ivory Coast
January 30, 2000

FDR PARAMETER LIST

A/C Tail Number	Month
A/C Type	N1-Eng1
APU Bleed Value	N1-Eng2
Aft CG Warning	N2-Eng1
Airspeed Computed	N2-Eng2
All Speed Ail-L/H	Normal Wing Anti-Ice-L/H
All Speed Ail-R/H	Normal Wing Anti-Ice-R/H
Alternate Wing Anti-Ice-L/H	Oil Quantity-Eng1
Alternate Wing Anti-Ice-R/H	Oil Quantity-Eng2
Angle of Attack	Outer Marker
Anti-Ice-Eng1	PLA-Eng1
Anti-Ice-Eng2	PLA-Eng2
Bleed Valve-Eng1	Pack 1 Mode Sel.
Bleed Valve-Eng2	Pack 2 Mode Sel.
C of G	Pitch
CMD-A/P1	Pressure Altitude
CMD-A/P2	Radio Height
CWS-A/P1	Reverser Deployed-Eng1
CWS-A/P2	Reverser Deployed-Eng2
Calibration	Reverser Unlock-Eng1
DFDAU BITE all 12 bits	Reverser Unlock-Eng2
DFDAU PG Number	Roll
Data Base Cycle	Rudder Pos
Data Base Day	Slats Fault
Data Base Month	Slats Pos
Day	Spoiler 1 & 4 Fault
EGT-Eng1	Spoiler 1 Pos-LH
EGT-Eng2	Spoiler 1 Pos-RH
EVM Fan-Eng1	Spoiler 2 Pos-LH
EVM Fan-Eng2	Spoiler 2 Pos-RH
EVM Turbine-Eng1	Spoiler 3 & 2 Fault
EVM Turbine-Eng2	Spoiler 3 Pos-LH
Elevator Pos-RH	Spoiler 3 Pos-RH
Event Marker	Spoiler 4 Pos-LH
Flaps Fault	Spoiler 4 Pos-RH
Flaps Pos	Spoiler 5 Fault
Fleet Identification	Spoiler 5 Pos-LH
Flight Number	Spoiler 5 Pos-RH
Frame Counter	Spoiler 6 Fault
Fuel Flow-Eng1	Spoiler 6 Pos-LH
Fuel Flow-Eng2	Spoiler 6 pos-RH
GMT	Spoiler 7 Fault
Gear Down-L/H	Spoiler 7 Pos-LH
Gear Down-Nose	Spoiler 7 Pos-RH
Gear Down-R/H	Squat Switch-L/H
Glide Slope Dev	Squat Switch-Nose
Gross Weight	Squat Switch-R/H
HF1	Stabilizer Position

HF2
Inner Marker
Land Track-A/P1
Land Track-A/P2
Lateral Accel
Localizer Dev
Longitudinal Accel
MACH No.
Magnetic Heading
Max Allowable Airspeed
Middle Marker

Start Valve-Eng1
Start Valve-Eng2
Sync code
Total Air Temp
VHF1
VHF2
VHF3
VMO/MMO
Vertical Accel
X-Feed Valve

APPENDIX C

Figures

Figure 8: A310 BITE Configuration



TSB/Canada

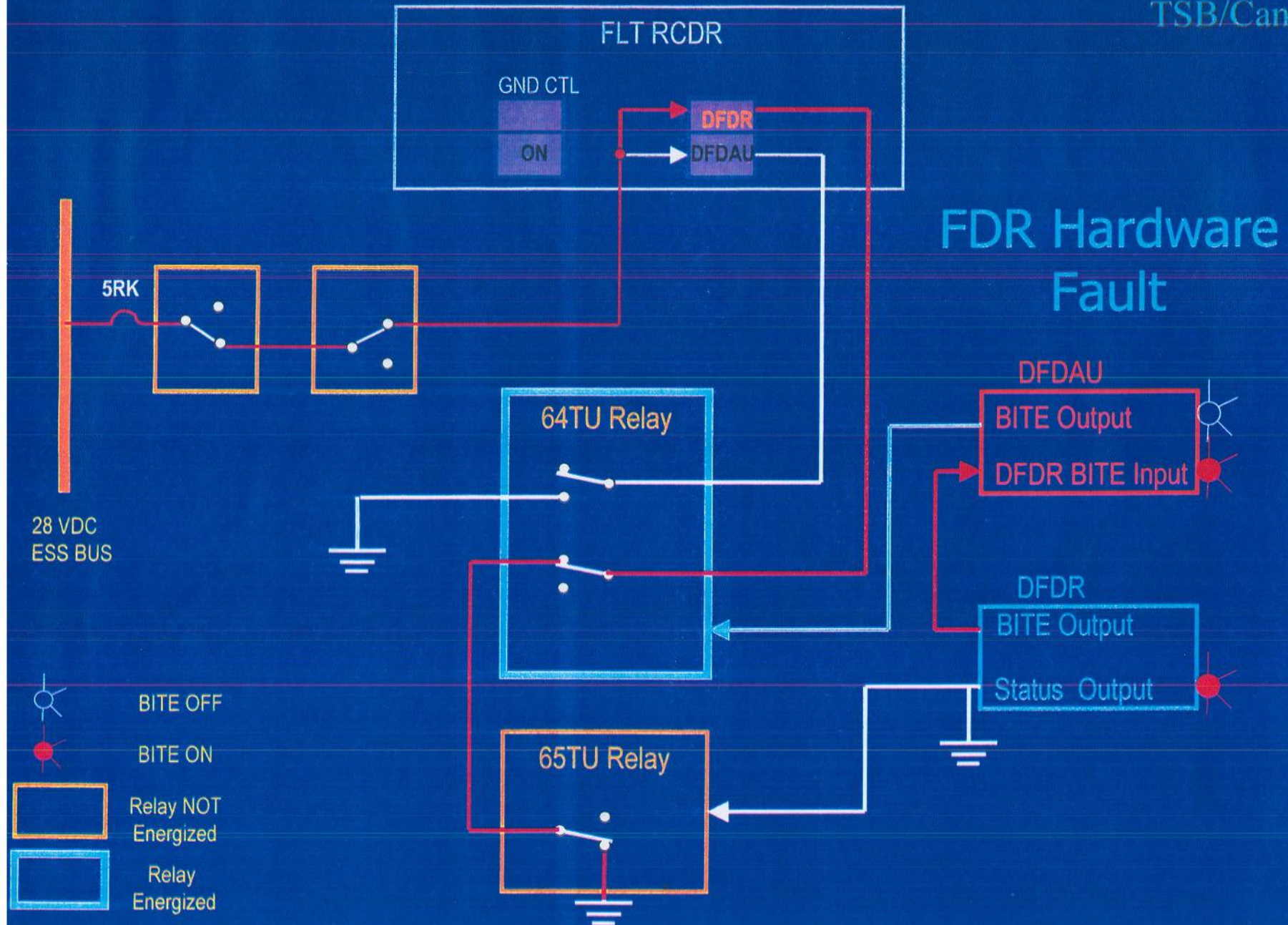
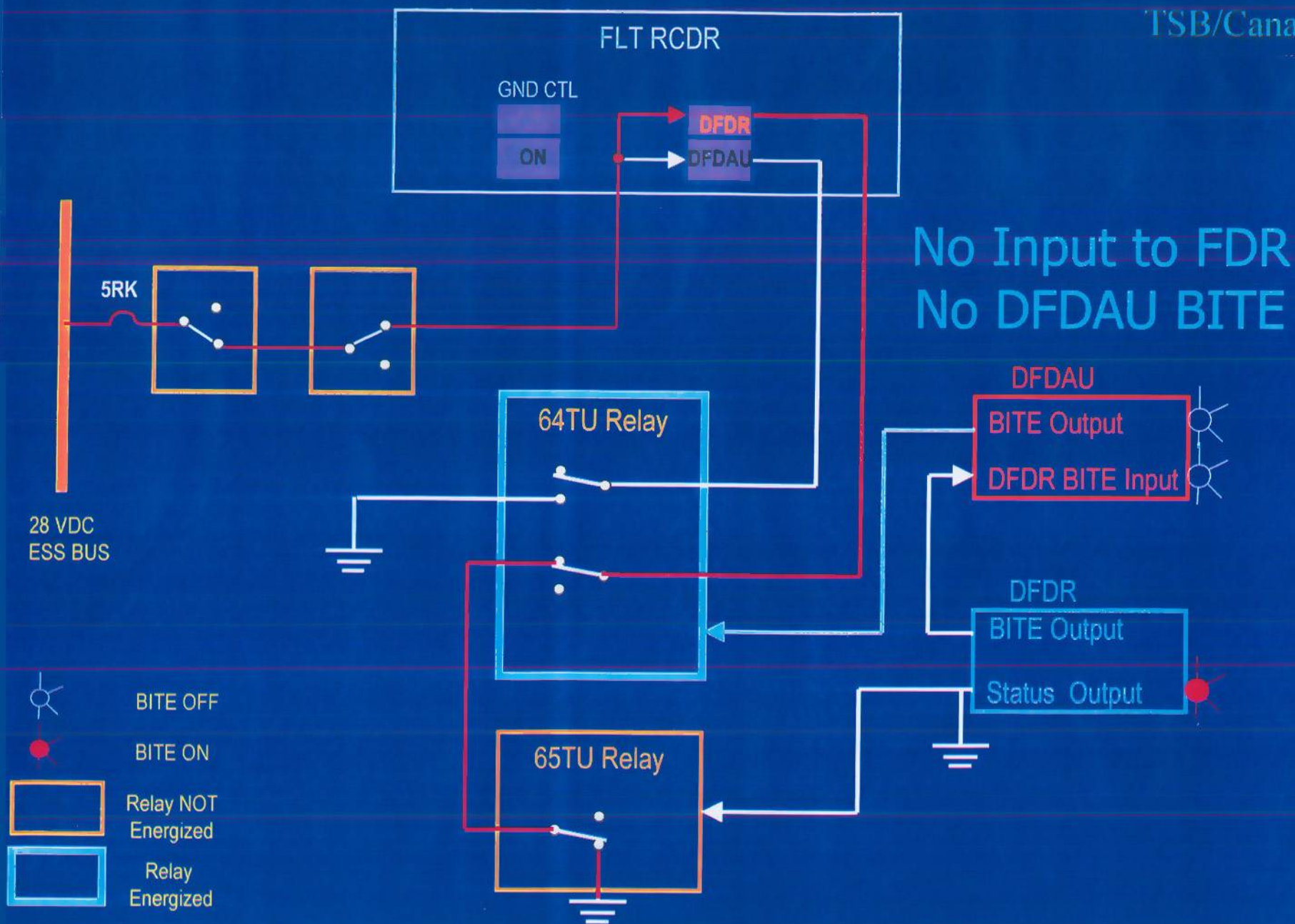


Figure 9: A310 BITE Configuration:



TSB/Canada



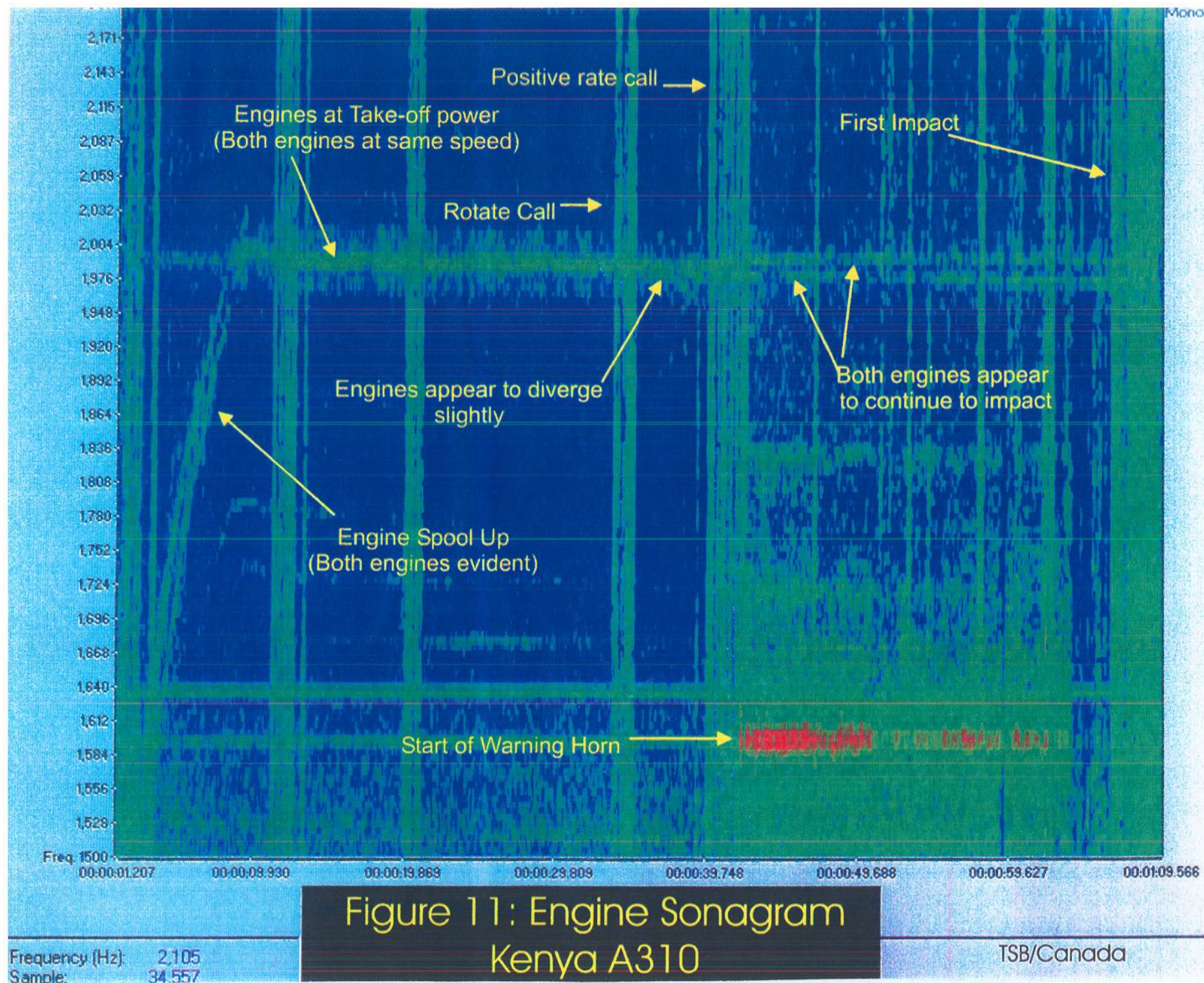
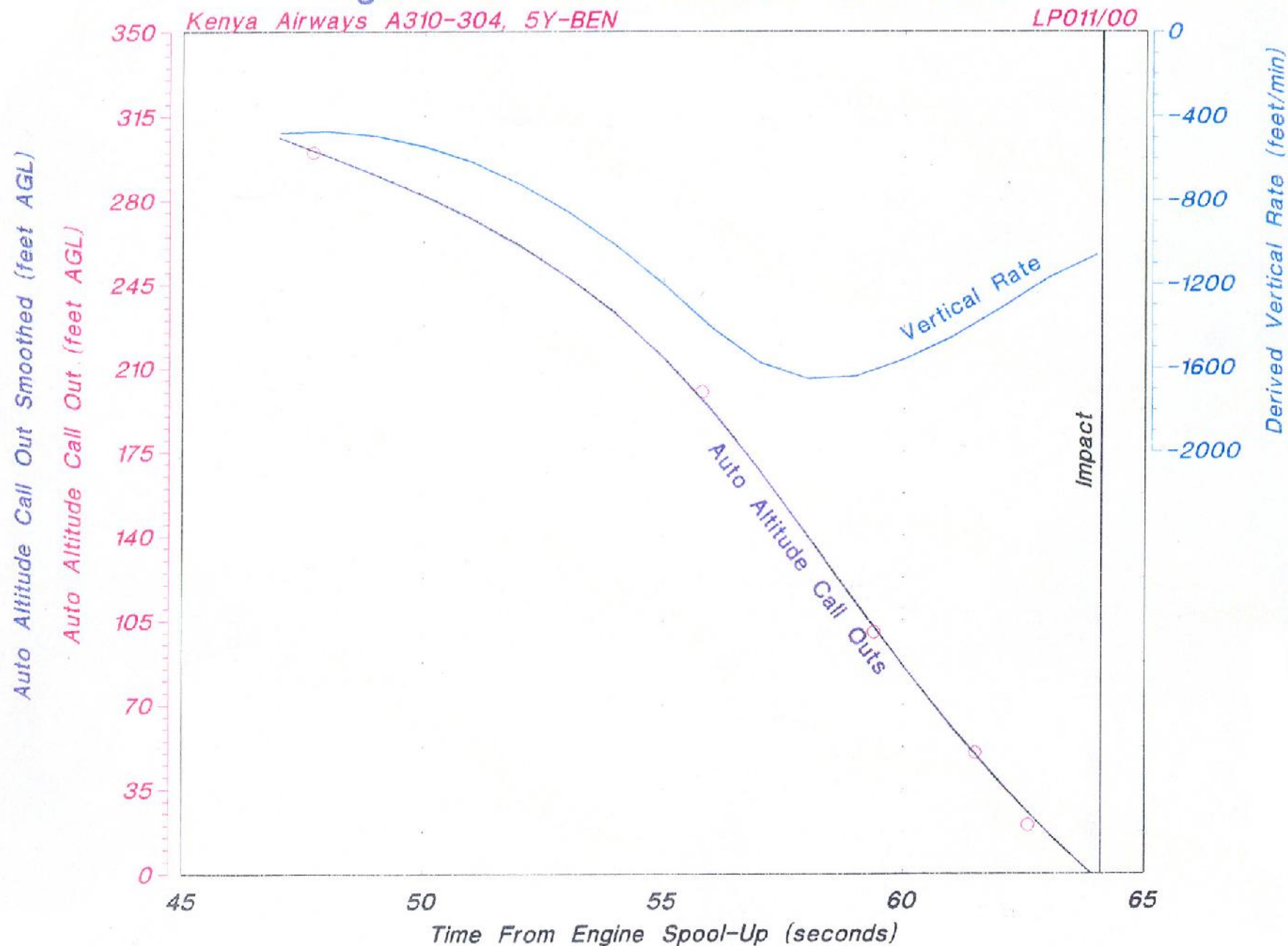


Figure 12: Auto Altitude Call Outs



APPENDIX D

Glossary

GLOSSARY OF ABBREVIATIONS USED IN THIS REPORT:

AC	.....	Alternating Current
AGL	.....	Above Ground Level
ATC	.....	Air Traffic Control
ATS	.....	Air Traffic Services
BITE	.....	Built In Test Equipment
CAM	.....	Cockpit Area Microphone
CVR	.....	Cockpit Voice Recorder
DFDAU	.....	Digital Flight Data Acquisition Unit
ECAM	.....	Electronic Centralized Aircraft Monitoring
EGT	.....	Exhaust Gas Temperature
EPR	.....	Engine Pressure Ratio
ESDU	.....	Engineering Science Data Unit
FLT RCDR	.....	Flight Recorder
GPWS	.....	Ground Proximity Warning System
hz	.....	Hertz
km	.....	Kilometers
KIAS	.....	Knots Indicated Airspeed
UFDR	.....	Universal Flight Data Recorder
UTC	.....	Coordinated Universal Time
V ₁	.....	Decision Speed

ANNEXE 14
TEMOIGNAGE

Monsieur GUEYE Mamadou, chef d'escale de KLM : Je supervise les opérations de KENYA AIRWAYS à ABIDJAN qui est lié à KLM par contrat de GSA. A ce titre, KLM supervise les opérations d'exploitation à l'aéroport d'ABIDJAN, où l'assistance est faite par AIR AFRIQUE.

L'avion a décollé à 21H08. Au moment où il partait en bout de piste, je suis monté à mon bureau. C'est de là que j'ai été informé du crash. Aussitôt, je me suis rendu au bureau de piste pour demander des renseignements. La confirmation du crash a été faite. De mon bureau, j'ai alerté les autorités aéroportuaires, KLM et KENYA AIRWAYS. Puis une cellule de crise a été mise en place afin d'organiser les secours.

L'avion venait de NAIROBI et devrait se poser à LAGOS mais a continué sur ABIDJAN à cause des mauvaises conditions atmosphériques régnant à LAGOS.

L'avion avait à bord 169 passagers et 10 membres d'équipage, soit au total 179 personnes. Après le crash, il a été dénombré 10 rescapés.

Les documents de vol de l'avion accidenté sont à la disposition de AIR AFRIQUE mais KLM en conserve une copie pour les besoins du service.

Monsieur DJIRE Omar technicien avion à AIR AFRIQUE : Le 30 janvier 2000 j'ai pris service à 17H00, l'avion était déjà au sol et je devais le prendre en compte uniquement pour le décollage. L'avion ayant à son bord un technicien accompagnateur, AIR AFRIQUE n'intervient techniquement que sur sa demande ; ce qui n'a pas été le cas ce jour là.

Le carburant a été fait sous l'assistance du technicien accompagnateur de KENYA AIRWAYS. A 20H00, j'ai mis en place le matériel de repoussage. A 21H00, j'ai repoussé l'avion pour le décollage. Au moment où il se dirigeait vers le point 21, je suis rentré au bureau. Vers 21H10, un collègue de service m'a appelé à la radio pour m'informer que l'avion venait de s'écraser en mer.

Je confirme que AIR AFRIQUE pas travaillé techniquement sur cet avion. les opérations ont consisté au repoussage

Monsieur SOUGALO Koné, chef du dépôt pétrolier : KENYA AIRWAYS a un contrat avec SHELL qui ravitaille régulièrement les avions de cette compagnie. Ainsi, le 30 janvier 2000 de 19H40 à 20H00, 23 854 litres de kérosène ont été servis à l'avion. Le ravitaillement s'est fait en présence du technicien accompagnateur de KENYA AIRWAYS

Monsieur ECRABE Julien, contrôleur de la Circulation aérienne : Le 30 janvier 2000, j'ai pris service à 19H42. A 20H55, le pilote de KENYA AIRWAYS a demandé la mise en route et le repoussage. Il a été autorisé. Ensuite, il a demandé le roulage mais au même moment, un Boeing 737 de Cameroun Airlines roulait pour la position 7B. J'ai demandé à KENYA AIRWAYS de céder le passage, ensuite de rouler, pénétrer et remonter la piste par la bretelle centrale et que je le rappellerai pour la clairance. Après, je l'ai autorisé à rouler.

Toutes ces instructions ont été collationnées par le pilote. Pour la clairance, j'ai dit au pilote qu'il est autorisé d'ABIDJAN à LAGOS via AFO AFO limite de clairance niveau de vol 230. Cela veut dire que l'avion peut partir d'ABIDJAN jusqu'à LAGOS en passant par le point AFO et monter jusqu'au niveau de vol 230 qui est son niveau maximum et le changement de niveau se fera avec le centre d'ACCRA. Le pilote a collationné. J'ai donc terminé la clairance en lui demandant de virer à gauche après le décollage et d'afficher au transpondeur le code 5040. Là aussi, le pilote a collationné en me demandant de confirmer le niveau de vol. Chose que j'ai répété deux fois. Le pilote a encore collationné.

La communication s'est momentanément interrompue jusqu'à ce que le pilote me rappelle prêt pour décoller. Je l'ai autorisé en lui donnant la piste et le vent et éventuellement me rappeler en passant le niveau de vol 40. Je regardais l'avion pendant qu'il roulait sur la piste pour décoller. J'ai constaté que le décollage était difficile parce que les roues ont quitté le sol pratiquement après la bretelle centrale. Je le suivais toujours du regard et sa montée semblait pénible. L'avion a semblé stabilisé quelques secondes et a commencé à perdre de l'altitude jusqu'à ce que je le perde de vue.

Il n'y a pas eu de conservation pendant la phase de décollage. Il n'y a pas eu non plus de signes particuliers qui pouvaient présager un éventuel crash. Cependant, la seule remarque que j'ai faite était sur le décollage qui s'est effectué après la bretelle centrale contrairement aux autres Airbus qui décollent généralement avant cette bretelle.

L'avion qui a décollé à 21H09 s'est écrasé à 21H10 ; c'est à dire, juste une minute après son décollage. Le déclenchement de la phase de détresse s'est fait à 21H10 selon les procédures en vigueur.

Le pilote a bien perçu le message de décollage qu'il a collationné. Malgré ses difficultés, le pilote n'a plus appelé.

Monsieur TOLA Angnimel Philippe, chef de sécurité incendie : Le 30 janvier 2000, vers 21H15, la tour de contrôle a déclenché l'alerte. Je me suis rendu à la base puis au bord de la mer où mes éléments se trouvaient déjà.

Je me suis déplacé avec tout mon arsenal de sauvetage et de sécurité incendie. J'ai fait avertir le

Groupement des Sapeurs Pompiers Militaires, la Marine Nationale et le 43^e BIMA avec qui nous avons des accords d'assistance mutuelle en cas de catastrophe.

Nous avons installé un groupe électrogène qui a une capacité d'éclairage sur 3.000 M² sur le littoral, ce qui a permis aux autres intervenants de s'installer. N'ayant pas de moyens d'intervention en mer, nous avons assisté à la communion des forces d'intervention dont la Gendarmerie, la Marine, le 43^e BIMA et du renfort venu de l'extérieur.

Sur insistance de certains riverains, j'ai dépêché quelques éléments vers la place du quartier Jean Folly où un des rescapés a été repêché et conduit au centre de santé de l'aéroport vers une heure du matin.

Vers trois heures du matin, je suis rentré à la base avec mes éléments pendant que les recherches se poursuivaient en haute mer car notre présence n'était plus nécessaire.

Nos interventions se font dans un rayon de huit kilomètres de notre base. Nous sommes les premiers intéressés s'agissant d'un crash d'avion. Mais, nous travaillons de concert avec les autres forces d'intervention qui disposent de moyens matériels appropriés.

Mon service n'a ni les moyens, ni la compétence d'intervenir en mer en cas de catastrophe.

Monsieur BIMENYI Mana Philippe, enquêteur le Tribunal International sur le Rwanda, rescapé :

Le 30 janvier 2000, je suis arrivé de mission de BRAZZAVILLE par AIR AFRIQUE à ABIDJAN. Quelques temps après, j'ai embarqué à bord de KENYA AIRWAYS pour NAIROBI où j'habite. Tout juste après le décollage, j'ai constaté que l'avion ne prenait pas de l'altitude comme il fallait. Bien au contraire, il perdait même de l'altitude et aussitôt, il y a eu coupure d'électricité.

Aucun membre de l'équipe ne nous a signalé quoi que ce soit et l'accident est arrivé. Après, je me suis retrouvé dans l'eau. J'ai nagé malgré mes différentes blessures. Je me suis accroché à quelque chose que je crois être un siège ou quelque chose provenant de l'avion. Après les sauveteurs sont arrivés pour me repêcher. Personne n'a pu nous prévenir de quoi que ce soit. L'accident est survenu très vite après le décollage.

Monsieur MADU Emmanuel, ingénieur et homme d'affaire, rescapé : Je venais de DOUBAI. Arrivé à NAIROBI, nous avons été transférés sur le vol à destination d'ABIDJAN via LAGOS. Arrivé à LAGOS, le Commandant de bord a dit qu'il continuait directement sur ABIDJAN.

A ABIDJAN, l'avion a passé près de six heures à sol. Avant le départ, d'autres passagers sont montés à bord. Au décollage, l'avion est parti comme si de rien n'était. Tout d'un coup, il est descendu de façon rapide dans l'eau à tel point que je peux vraiment pas dire exactement ce qui s'est passé.

A peine sorti à la surface de l'eau, je me suis accroché à un débris de l'appareil sur lequel je suis resté jusqu'à l'arrivée des sauveteurs. Sincèrement parlant, j'ai tout perdu dans cet accident, mais compte tenu du fait que j'ai été sauvé par le tout-puissant, je m'en remets aux autorités concernées par cette affaire.

Madame Francisca Gyindobla SAMBO, rescapée : Je suis montée à bord de l'airbus à DOUBAI à destination de LAGOS. L'Avion a fait une escale de deux à trois heures à NAIROBI. Après le décollage, la seconde escale était prévue pour LAGOS. A l'approche de LAGOS, l'équipage a fait une annonce en disant que pour des raisons d'intempérie, l'atterrissage était impossible et qu'il ne se posera qu'à ABIDJAN. Ainsi, après quelques heures de vol, l'avion s'est posé à l'aéroport d'ABIDJAN. Certains passagers sont descendus et d'autres sont montés. Après six heures d'escale, l'avion s'est dirigé sur la piste pour le décollage. Puis, une voix d'homme nous a demandé d'attacher les ceintures de sécurité pour un décollage imminent. Comme d'habitude, les hôtesses ont fait des passages de vérifications pour savoir si tous les passagers avaient attaché les ceintures. Tout étant terminé, j'ai senti que l'avion était prêt pour le décollage. En quelques secondes, l'avion a décollé et s'est dirigé sur la mer.

Malheureusement, trois minutes de vol après, l'avion a commencé à perdre de l'altitude. Il descendait de façon vertigineuse et je voyais monter la mer vers l'avion. Tous les passagers étaient paniqués. Juste le temps de me rendre compte, l'avion a fait une plongée dans la mer suivi d'un bruit sourd. Pendant une dizaine de secondes, j'avais perdu connaissance. Revenue à moi-même, je me suis retrouvée dans l'eau comme plusieurs autres passagers. J'ai essayé de revenir en surface. Heureusement, avec beaucoup d'efforts, je suis sortie en surface où j'entendais des cris.

La première des choses que j'ai vues, c'est mon sac qui était avec moi. Je me suis agrippée et un moment, j'ai commencé à descendre avec le sac. J'ai vu des cousins des sièges, j'ai saisi un, mais c'était peine perdue. J'ai essayé plusieurs objets sans succès. Comme par hasard, j'ai aperçu un débris de l'appareil que j'ai saisi avec précaution. J'ai tout de même bu de l'eau diluée de kérosène et je me sentais étouffée. J'ai toujours continué de me battre et à un moment, je ne sentais plus mes jambes à cause de l'eau glaciale.

Deux heures plus tard, j'ai aperçu les phases d'hélicoptères passer au-dessus de nous sans nous voir. De loin, je voyais les lumières d'un bateau. Progressivement, le bateau venait vers nous. Après trois ou quatre heures de temps, le bateau est arrivé à côté de moi. Je voyais ses occupants faire des gestes que je ne peux pas décrire tellement j'étais fatiguée et traumatisée. Je n'arrivais donc pas réaliser ce qui se passait. J'ai vu un des occupants du bateau jeter un ballon gonflable vers moi après avoir entendu mes appels.

J'ai été la première à être ramenée à bord du bateau. Les sauveteurs me parlaient mais j'étais à demi inconsciente. Sans tarder, ils m'ont ôté mes vêtements qui étaient imbibés d'eau et de kérosène. J'ai été couverte d'un drap et ils ont tenté de me perfuser. Pendant près de vingt minutes, mes veines

étaient introuvables. J'avais sommeil et je somnolais. Les sauveteurs m'ont demandé de ne pas dormir pour des raisons médicales. Ensuite, je me suis retrouvée à l'hôpital où j'ai été hospitalisée.

Au départ, tout semblait bien concernant l'avion. Après trois ou quatre minutes de vol, l'avion a commencé à descendre de façon anormale.

Monsieur ISSA Mamadou Diakité, manutentionnaire : Le jour du crash, l'avion est arrivé plus tôt que prévu, à cause, paraît-il, du mauvais temps à LAGOS, il n'a pas pu atterrir et est venu directement à ABIDJAN. A l'arrivée, il y avait deux containers dans la soute arrière, un pour ABIDJAN et un pour LAGOS. On a débarqué celui d'ABIDJAN et laissé le container de LAGOS à bord. A l'avant, il y avait, je crois, deux palettes et deux containers, tous à destination de LAGOS.

Quand on a fini, il y a eu un temps mort. Puis, on nous a informé qu'il y avait des passagers qui devaient partir sur ACCRA par un vol de GHANA AIRWAYS qui entre temps s'est posé à ABIDJAN. Les passagers du vol KQA qui devaient descendre à LAGOS pour prendre un vol sur ACCRA ont préféré prendre le vol de GHANA AIRWAYS. Ils ont demandé que les bagages soient débarqués du vol KQA ; ce qui a été fait, puis nous avons refermé les containers.

Au départ d'ABIDJAN, nous avons embarqué un container pour LAGOS ou NAIROBI, je ne sais pas, en soute containers plus un cercueil en soute vrac. Et dès qu'on a fini de traiter le vol, on a retiré les engins : tapis, passerelle, etc.

L'avion est parti en bout de piste puis a amorcé son décollage. Après on a entendu « Ah ! Ah!, on dirait que l'avion va tomber ». Pendant ce temps l'avion faisait une courbe à destination de la mer.

Le manutentionnaire dans le cas des AIRBUS, entre dans la soute vrac, fait descendre les bagages de l'équipage et fait glisser sur le tapis les bagages des passagers s'il y en a. Un autre manutentionnaire en bas les réceptionne pour les mettre sur un chariot.

En gros le manutentionnaire s'occupe des bagages. Mais, il aide souvent le conducteur d'engin à l'intérieur de la soute.

ANNEXE 15
FCOM (CHAPITRES 2.02.09 ET 2.04.10)

AIRCRAFT LATERAL TRIMMING

The minimum drag is obtained when the ailerons and control wheel are in the neutral position. This condition is obtained by the following procedure, provided slats are retracted :

- Ensure symmetric fuel loading,
- Disconnect A/THR (using instinctive disconnect pushbutton)
- Ensure accurate symmetric thrust,
- Engage the autopilot in CMD, if not already engaged, in HDG SEL mode and in ALT HLD mode,
- Adjust the rudder trim in order to obtain a zero control wheel position (aileron deflection scale on the wheel),
 If the required rudder trim deflection exceeds 1.5°, a log book entry should be performed for maintenance action.
- Check bank angle, if bank angle is estimated to exceed 2°, a log book entry should be performed for maintenance action,
- Check again the lateral trimming conditions and retrim if necessary when ever there is a noticeable change in flight conditions (e.g. step climb).

R
R
R
R
R
R

RECOVERY FROM STALL WARNING (STICK SHAKER)

Whenever a stall warning (i. e. Stick Shaker activation) is experienced at low altitude, this should be considered as an immediate threat to maintaining a safe flight path.

Indications :

- Stick Shaker activation
- Speed symbol in the red and black strip on PFD speed scale

At the first indication of an impending stall or upon stick shaker activation, perform simultaneously the following actions :

THRUST LEVERS TOGA
 PITCH ATTITUDE REDUCE

- If a risk of ground contact exists, do not reduce the pitch attitude more than necessary to allow airspeed to increase.
- After initial recovery, maintain the speed close to the stick shaker speed until it is safe to accelerate (closely monitor both the speed and the speed trend arrow).

BANK ANGLE WINGS LEVEL
 SPEED BRAKES CHECK RETRACTED

- If below 20000ft and in clean configuration :
 SLATS EXTEND

- When out of stall and if no threat of ground contact :
 LANDING GEAR (if DOWN) UP

Recover normal speed and select flaps as required.

- If one engine inoperative :
 POWER AND RUDDER USE WITH CARE

R
R

PROCEDURES INITIATION

- No action shall be taken (apart from audio warning cancel) until :
 - R – The appropriate flight path is stabilized,
 - Normal procedures are applied,
 - At least 400 ft above runway, in case of failure during takeoff, approach or go-around,
- R • A height of 400 ft is recommended as a good compromise between :
 - R * the time required for flight path stabilization,
 - R * the initiation of the procedure without excessive delay.
- R • In some emergency conditions, provided the appropriate flight path is established, the PF may initiate actions before reaching 400 ft AGL.
- R – Appropriate command by PF.

TASK SHARING

- The Pilot Flying (PF) remains PF throughout the entire procedure.
- However, when actions can only be performed from one side (e.g. landing gear gravity extension, minimum equipment bay sniffer fan), tasks must be redistributed accordingly.
 - The PF (Pilot Flying) is responsible for :
 - Throttle levers,
 - Flight path and airspeed control,
 - Aircraft configuration (PF orders, PNF executes),
 - Navigation,
 - Communications.
 - The PNF (Pilot Non Flying) is responsible for :
 - Reading the ECAM and QRH,
 - Execution of ECAM actions and paper check-list(s), upon PF command,
 - Actions on fuel levers, fire handles and guarded switches (with confirmation of PF).

Note : During a rejected takeoff, an on-ground engine fire or an on-ground emergency / evacuation, a CAPT-F/O task sharing applies.

Note : Memory Items may be carried out by either pilot, since response time may be important for success. However, initiation of Memory Items must be called out by the PF.

- Whenever a procedure calls for LAND ASAP, landing at the nearest suitable airport (considering the applicable LDG DIST factor, if any) must be considered.
- Following a fire or smoke condition, landing at the nearest suitable airport is recommended even if the fire (smoke) source has been successfully extinguished (stopped).
- If the fire or smoke source cannot be extinguished (stopped) or if extinction cannot be positively confirmed, landing at the nearest suitable airport must be considered.

LDG SPEED INCREMENT - LDG DISTANCE FACTOR

- The LDG SPEED INCREMENT is to be added to the indicated V LS.
 - A V LS increment is indicated on the ECAM STATUS page and in the FCOM / QRH procedure only when the indicated V LS does not account for the abnormal condition, this is the case only in the following two conditions :
 - Kruger flaps not extended when selected,
 - or
 - Loss of 4 or more roll spoilers per wing.
- In all other abnormal conditions, the indicated V LS accounts for the abnormal configuration.

ANNEXE 16**CAS D'ACTIVATION DE L'ALARME DE DECROCHAGE HORS SITUATION REELLE DE
DECROCHAGE SURVENUS PRECEDEMMENT**

A la requête de la Commission d'enquête, le BEA a demandé à la compagnie aérienne Air France qui a fourni une liste d'événements similaires survenus sur les avions de sa flotte.

Type d'aéronef	Description de l'événement
B737-500	Au décollage, fonctionnement intempestif du stick shaker. Lors de la rentrée des volets avec une vitesse d'alarme de décrochage. ADI CDB (bande rouge et noire), incohérente (supérieure à 250 nœuds). Fonctionnement erratique de l'auto manette. Activation du stick shaker pendant l'approche et l'atterrissage. Au sol, la sonde d'incidence gauche a été trouvée cisailée et pendue au fil de réchauffage. La sonde était proche de la passerelle avant son retrait à ZRH.
B737-500	Pendant le décollage (60 nœuds) le voyant LE TRANSIT ambre avec indication volets sur 1 apparaît. La vérification de l'indicateur LE DEVICE du panneau supérieur qui est OK tout vert. Il n'y a pas d'alarme de configuration qui retentit. La poursuite du décollage est décidée. Au lift off apparition du stick shaker. Une correction d'assiette immédiate arrête l'alarme. Commentaires : L'alarme du stick shaker a été pour le pilote le résultat d'une fausse alarme (LE TRANSIT) et non pas d'une configuration réelle de l'avion.
B737-500	Activation du vibreur de manche lors du roulage, avion au sol vers 90 nœuds.
B737-200	A VR alarme STALL WARNING vibreur de manche activé, vitesse anémo secours correcte. Poursuite du vol : impossibilité d'arrêt d'alarme et vibreur. Demi tour sur CDG.
B747-200	Au cours du décollage vers 50 nœuds, apparition du vibreur de manche. Arrêt décollage. Remplacement computer stall warning.
B737-500	Déclenchement bref du vibreur de manche après le décollage, à 100 nœuds. Tous paramètres normaux, pas de phénomène météo ressenti, aucune explication satisfaisante trouvée.
A310	Après décollage, pendant la rentrée du train, activation du vibreur « GPWS » allumé. Vérification de tous les paramètres anémométrique : RAS. Stick shaker neutralisé en tirant le breaker correspondant suivant la C/L « inadvertent stick shaker ». A l'arrivée à ORY pendant la séquence sortie volet et train, réactivation de l'alarme audio "Gong répétitif".

ANNEXE 17

NOUVEAU MANUEL D'ENTRAINEMENT DES EQUIPAGES D'AIRBUS,
VERSION DECEMBRE 2000, CHAPITRE 1.03.27

AIRBUS INDUSTRIE <small>Training & Flight Operations Support Division</small> A310/A300-600 FLIGHT CREW TRAINING MANUAL	ABNORMAL OPERATION BRIEFINGS FLIGHT CONTROLS	1.03.27 Page 3 REV 20 DEC 2000
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RECOVERY FROM APPROACH TO STALL

01 - TRAINING OBJECTIVE

- To recognize the indications of an impending stall.
- To take immediate and appropriate actions to recover to controlled flight.

02 - DURATION

- 20 minutes

03 - TRAINING REFERENCES

Documentation :

- FCOM 1.10.93 - FLIGHT INSTRUMENTS
- FCOM 1.09.12 - FLIGHT CONTROLS
- FCOM 2.02.09 - PROC. & TECH.

04 - REMARKS

- A dual stall warning system activated by FWC provides audio and stick shaker warnings in case of impending stall. Activation depends on the AoA and slats configuration :

A 310 :

- AoA > 10° clean
- AoA > 17.5° other config.

A 300/600:

- AoA > 8.5° clean
- AoA > 15° other config.

Speed symbol in red and black strip on PFD speed scale.

- Angle of Attack protection :
 - ATS levers disarmed no protection
 - ATS levers at least one lever armed Alpha floor protection.
- The THS can be commanded automatically by the FAC at high angle of attack :
 - Alpha trim, Nose down order to increase the pull-up stick force and prevent reaching an excessive angle of attack. The alpha trim is available in clean configuration with the A/P off.
 - Stall trim, Nose down order to assist the stall recovery.
- At stick shaker activation, even with reduced lift margins, an aircraft still has positive performance capability. So instead of trying to recover in minimum time by power application and pitch down, the technique recommended is a minimum loss of altitude by power application and flying optimum pitch.

AIRBUS INDUSTRIES <small>Ticketing & Flight Operations Support Division</small> A310/A300-600 FLIGHT CREW TRAINING MANUAL	ABNORMAL OPERATION BRIEFINGS FLIGHT CONTROLS	1.03.27 Page 4 REV 20 DEC 2000
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RECOVERY FROM APPROACH TO STALL (CONT'D)

04 - REMARKS (CONT'D)

- The FPV can be of a great help in controlling flight path so as to minimize the height loss during recovery. Pitch attitude should be then adjusted to hold FPV on or close the horizon.
- Use the maximum thrust allowable. Pitch up is noticeable with thrust application, move the control column to smoothly adjust the pitch attitude as necessary during the recovery. Avoid abrupt control inputs they may induce a secondary stall.
- In landing configuration do not retract the gear until Speed > VLS and positive climb. The gear retraction sequence (doors and gear) induces undesirable drag which leads to a transient reduction of climb angle of approximately 1°.
- Retracting the flaps is not recommended especially when near the ground, as a greater altitude loss will result during recovery.

Approach to stall entry :

- ATS disengaged
- Thrust levers idle
- Adjust pitch attitude to produce -10 kt long speed trend arrow
- Do not trim below VLS

Recovery technique :

If above 20 000 ft, clean configuration, no risk of ground contact :

Apply at the first indication : Stall warning or buffet or stick shaker

- Thrust levers full forward.
- Smoothly roll wings level.
- Select pitch attitude 0 to 5° nose down to produce + 15 kt long speed trend arrow.
- When speed above Green dot, smoothly adjust a climb.

If below 20 000 ft, clean configuration, risk of ground contact :

Apply at the first indication : Stall warning or buffet or stick shaker

- Thrust levers full forward
- Smoothly roll wings level
- Select slats 15°
- Smoothly achieve pitch 10° nose up
- When risk of ground contact no longer exists and speed above VLS adjust pitch to accelerate and clean up in normal manner.

RECOVERY FROM APPROACH TO STALL (END)

04 - REMARKS (END)

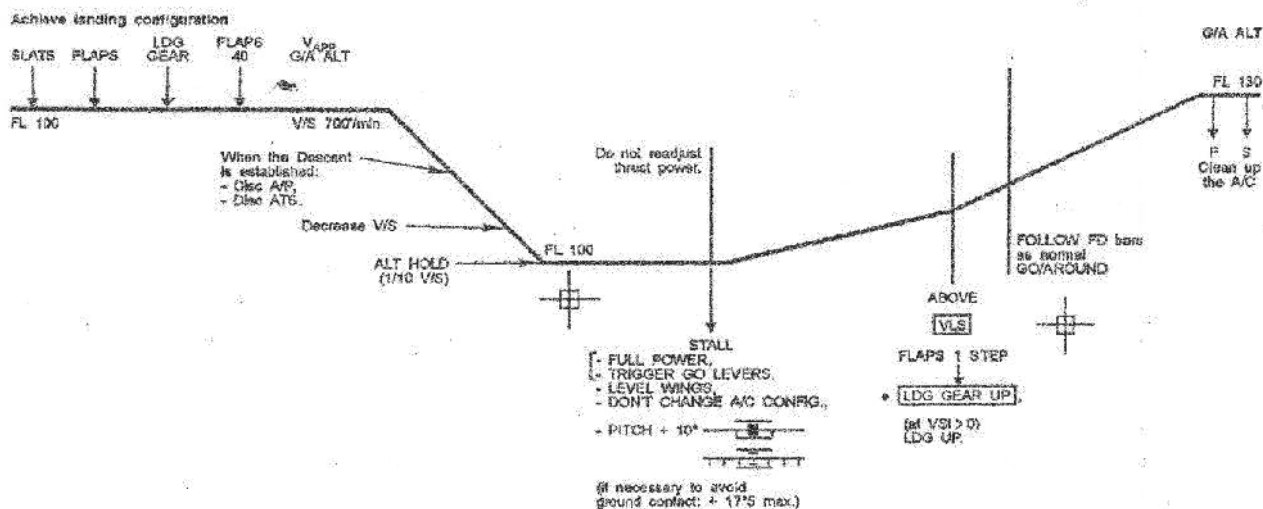
Below 20 000 ft, landing configuration :

ALWAYS TREAT AS RISK OF GROUND CONTACT

Apply at the first indication : Stall warning or buffet or stick shaker

- Thrust levers full forward (TOGA)
- Smoothly roll wings level
- Trigger go-levers (strong pitch up tendency occurs as the thrust increases, forward pressure on control is necessary)
- Smoothly adjust pitch to minimize the rate of descent : 10° nose up (maximum 17.5°)
- When risk of ground contact no longer exists and speed is above VLS
- Retract flaps one step, select the landing gear up and continue the recovery on the same way as a go-around procedure.

LANDING CONFIGURATION



(27.PCX)