

F I N A L R E P O R T

concerning the accident
which occurred on June 26th 1988
at Mulhouse-Habsheim (68)
to the Airbus A 320, registered F-GFKC

November 29th 1989

FOREWORD

-:-:-

This report is a technical document which reflects the point of view of the Investigation Commission set up by the Minister of Transport to investigate the circumstances in which the accident occurred, its causes and its consequences.

In compliance with Appendix 13 to the Convention, on International Civil Aviation, the investigation in no way tries to establish faults or responsibilities. It has been conducted without necessarily using contradictory proceedings and with the basic aim of preventing future accidents.

SPECIAL FOREWORD TO ENGLISH EDITION

This report has been translated and published by the French Bureau Enquêtes-Accidents to make its reading easier for English speaking people. As accurate as the translation may be, please refer to the original text in French.

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SYNOPSIS

Date of accident

Sunday June 26th 1988
at 12 h 45 UTC (1)

Aircraft

Airbus A 320
MSN : 9
Registration : F-GFKC

Place of accident

300 m beyond the end of runway
34 R at the MULHOUSE HABSHEIM
aerodrome (68) and on runway
axis.

Owner

DURUS VERWALTUNGSGESELLSCHAFT
MBH Co MOBILLEN KG

Operator

AIR FRANCE

Type of flight

Chartered flight
Public transport of passengers
including a low altitude
flyover.
Flight No. and radio telephone
code : ACF 296 Q

Occupants

* Flight crew : 2
* Cabin attendants : 4
* Passengers : 130

Summary of accident

As part of an airshow, the aircraft flew over runway 34 R at a height of approximately 30 feet, engines at idle, with an angle of attack increasing up to the maximum possible taking into account the deceleration rate of the aircraft. During the go-around, the aircraft touched the trees a short way beyond the end of the runway, sank into the forest, came to rest and caught fire. Evacuation was undertaken immediately but three passengers died in the fire.

Consequences

	P E R S O N S			Aircraft	Third party damage
	Killed	Injured	Unhurt		
Crew	0	2	4	Total loss	Approximately two hectares of forest destroyed
Passengers	3	34 (*)	93		
Third parties	0	0			

(*) Passengers taken to hospital.

(1) The times given in this report are in universal time coordinated (UTC).
Add two hours to obtain legal French time.

COMPOSITION OF THE INVESTIGATION COMMISSION AND SUMMARY OF WORK

Composition of the Investigation Commission

By order dated June 27th 1988, the Minister of Transport set up an Investigation Commission composed of :

Messrs Claude BECHET -	President Captain Bureau Enquêtes Accidents
François GONIN -	Ingénieur Général de l'Armement Vice-President
Robert AUFFRET -	Médecin Général Member of the Civil Aviation Medical Council
Bernard FARTHOUAT -	Ingénieur Général de la Météorologie
Paul ARSLANIAN -	Ingénieur en Chef de l'Aviation Civile
Philippe GOURGUECHON -	Pilot Inspector
Jean-Paul de VILLENEUVE -	Engineer Bureau Enquêtes Accidents

whose mission was to study the circumstances and find the causes of, and release information relevant to, the accident which occurred on June 26th 1988 at Mulhouse-Habsheim to an Air France A 320 aircraft.

In accordance with the provisions of the protocol concerning technical investigations of accidents involving aircraft equipped with CFM 56 engines, signed jointly on March 21st 1985 by the Accident Investigation Bureau (BEA) of the Civil Aviation General Inspectorate and the National Transportation Safety Board (NTSB-USA), a delegate of the country co-manufacturing the Airbus engines, assisted by three technical advisers, was called on to participate in the Commission's work.

Also, in a decision taken by the President of the Commission, Mr Jean-Claude WANNER, general engineer armament, joined in the Commission's work as an expert in human factors.

Summary of work

The French Accident Investigation Bureau (BEA) was informed of the accident around 13 h 30 on Sunday June 26th. After having taken all measures to safeguard the evidence, two investigators from this office were sent immediately to the site of the accident. They arrived there around 16 h.

On their arrival at the Mulhouse-Habsheim aerodrome, they got in contact with the local aeronautical, prefectorial and judicial authorities and started work in collaboration with these authorities.

The recorders had been recovered by the rescuers. They were transferred overnight to Paris, as their analysis required specialized installations and technicians.

Tuesday June 28th : the President of the Commission held a first hearing with the flight crew and listened in their presence to the recordings made on the cockpit voice recorder.

The first full session of the Commission was held in Paris on Wednesday June 29th. All the members of the Commission were present.

This session permitted all the research and study work to be shared out between the Commission members.

The following day, Thursday June 30th, two members of the Commission flew to Mulhouse Habsheim in a light aircraft belonging to the administration and made around ten flights over the wreckage under the flight conditions of the accident.

On this occasion, contacts were also made with the Colmar prefectorial authorities and the examining Judge in charge of the affair.

A second full session was held on Friday July 1st during which participation of NTSB was confirmed in accordance with the protocol mentioned above.

From July 4th to 7th, the accredited representative from the USA and his three technical advisers participated in the work of the Commission, became acquainted with the reading out of the flight data recorder and all information that was available at this stage in the investigation.

This delegation left for Washington on July 7th 1988 without leaving a delegate in situ as had been proposed.

The following weeks were devoted to studying the circumstances of the accident. The work especially consisted in examining the recordings, hearing the pilots and the authorities concerned and reconstructing the parameters of the accident in the simulator and in flight on July 20th and 21st. This led to the writing of the preliminary report which was handed over to the Minister of Transport on July 28th 1988.

The Commission then continued their study and analysis of the accident.

Full sessions of the Commission were held on July 19th 1988, September 6th 1988, October 27th 1988, December 20th 1988, April 27th 1989, June 21st 1989, June 26th 1989 and September 13th 1989. The Commission also released an official statement on November 2nd 1988 giving the progress made in their work. The Commission approved the present final report during their session held on November 29th.

In compliance with the clauses of the interministerial order dated January 3rd 1953, the Commission carried out all their work in close cooperation with the judicial authorities (Public Prosecutor*, Examining Judge, judicial experts, Air Transport Police, Air and Frontier Police). Judicial experts were invited to all the Commission's sessions and participated in much of its work.

In compliance with the terms of the order dated November 3rd 1972 relevant to investigation commissions, the draft of the final report was submitted, for comments, to the following persons and organizations :

- Crew members (flight crew and cabin attendants)
- Air France
- Airbus Industrie
- CFMI
- Mulhouse flying club
- Direction Générale de l'Aviation Civile (D.G.A.C.)
- Haut-Rhin préfecture

The two flight crew members declared that they wished to reserve their comments for the judicial representatives.

* American equivalent is the Attorney General

1 - FACTUAL INFORMATION

1.1 - HISTORY OF THE FLIGHT

On June 26th 1988, the Air France A 320 F-GFKC was to perform for Air Charter a series of flights with passengers on behalf of the Mulhouse flying club.

The program included the following flights : Paris-Charles de Gaulle/Basle-Mulhouse, 2 round trips from Basle-Mulhouse and the Basle-Mulhouse/Paris-Charles de Gaulle return flight.

At the start of each of the two round trips, initially planned to the Vosges area, then, for meteorological reasons, to the Alps, the crew was, at the request of the Mulhouse flying club, to overfly the Mulhouse-Habsheim aerodrome as part of the air show organized by this flying club.

The regional Air France delegation at Mulhouse, acting as contact between the organizer of the air show and the carrier Air Charter, had made the administrative preparation for the flight.

In Paris, Air Charter took charge of the commercial aspects, defining the general flight conditions (route, choice of aircraft on the basis of Air France availabilities) and preparing the contract.

Lastly, the technical preparation was undertaken by the "Service Ligne et Régions de la Direction des Opérations d'Air France" who, on the basis of commercial requests, studied the conditions under which the flight was to be performed and prepared the technical file for the crew.

According to the declarations made by the airline, this preparation was made with respect to the specific airline directives (internal note DOND 50420 dated October 19th 1987 shown in appendix), taking into account the obstacles and with a planned low altitude flyover of runway 02.

On completion of this study, on Friday June 24th in the afternoon, the A 320 Flight Division, i.e. the department responsible for crew management, received the following file intended for the crew together with verbal comments :

- IGN (National Geographical Institute) map, scale 1/100,000
- visual flight chart, scale 1/500,000
- visual landing chart (VAL) of Mulhouse Habsheim airfield
- scheduled flight plan
- copy of various messages.

In this documentation, there were no instructions either concerning runway axis or height of overflight.

On Sunday morning, June 26th, during their flight preparation, the crew became acquainted with the file. No verbal comments were made to them.

The flight from Paris-Charles de Gaulle to Basle-Mulhouse was achieved normally.

After a short stop, the aircraft departed shortly before 12 h 30 for the first round trip.

For this flight, the pilot in the left seat was the designated Captain, and he had the controls.

During taxiing, as confirmed by the recording of on-board conversations, he explained in detail the program of the flyby to be made at Habsheim (first overflight at low speed, with landing gear and flaps extended, at a height of 100 feet, then overflight at high speed in clean configuration). The intention to make two overflights was transmitted to air traffic control by radio.

Take-off was made at 12h 41, immediately followed by a right turn to reach Mulhouse Habsheim at an altitude of 2000 feet QNH (i.e. a height of approximately 1000 feet above the ground) achieved at 12h 42.

During the level flight at 1000 feet above the ground, the autothrottle was disengaged to permit manual control of the thrust, and two warning sequences, related to the landing gear retracted configuration and two indications of radio altimeter height less than 1000 feet, were heard. The motorway was used as the first visual navigation landmark then a track, parallel to the motorway, leading to the Habsheim aerodrome.

At 12h 44, the aircraft left this level flight altitude and descended towards the aerodrome which was identified visually. The engines were throttled back. Flap and landing gear were extended at start of descent.

Setting of the pressure at aerodrome level (i.e. 984 hPa) was made and counterchecked by the two pilots.

The vertical speed during descent was 600 feet per minute.

Confirmation of Habsheim aerodrome identification was made at 450 feet above the ground.

A warning related to the radio altitude and flap 3 configuration was recorded before a first aural altimeter message "200 feet" at 12h 45mn 06s. A second aural message "200 feet" interrupted a personal remark made by the First Officer at 12h 45mn 11s. The First Officer informed the Captain that the aircraft was reaching 100 feet at 12h 45mn 14s and simultaneously the radio altimeter emitted a "100 feet" message, the vertical speed still being 600 feet per minute.

The descent continued at a slightly lower rate down to 50 feet, reached 8 seconds after passing through 100 feet agl*, then at a very low rate down to 30 to 35 feet above the ground, the aircraft then remaining more or less in level flight.

Throughout the whole descent and at the start of level flight made with engines set to flight idle, the aircraft decelerated and its pitch up increased during the last 25 seconds of flight. The end of the descent and the level flight were made above runway 34R. Between 12h 45mn 34s and 12h 45mn 35s, the engine controls were set to initiate go around (the acceleration of the engines can be seen on the flight data recorder at 12h 45mn 35s).

The aircraft touched the trees shortly after the end of the runway at 12h 45mn 40s ; at this time, engine speed was around 83 % N1, the pitch attitude of the aircraft was 14°.

The first contact between the aircraft and the trees was made by the rear section of the fuselage, the tailplane then the engine nacelles and the main landing gear. The aircraft sank slowly into the forest. The tip of the right wing then the right wing itself broke, fuel was projected forward and fire immediately broke out and penetrated the cabin as soon as the aircraft came to rest.

Evacuation was made immediately via the left side. The forward left door could not be opened completely because of the trees. The left aft door opened correctly and the escape slide deployed normally but was perforated by the broken trees as soon as used by the first evacuees.

A woman and two children, including one physically handicapped, died in the fire.

* above ground level

1.2 - INJURIES TO PERSONS

	Crew	Passengers	Third party
Killed.....	0	3	0
Injured....	2	34 (1)	0
Unhurt.....	4	93	

(1) Passengers taken to hospital

1.3 - DAMAGE TO AIRCRAFT

The aircraft was totally destroyed by the successive impacts and the very violent fire which followed.

1.4 - OTHER DAMAGE

Approximately two hectares of forest (5 acres) (young oak and birch) were destroyed. The trees were broken, torn or burnt. Others were cut during the rescue and wreck recovery operations.

1.5 - PERSONNEL INFORMATION

The crew included two pilots, in accordance with the aircraft operating rules, both Captains and with management responsibilities.

1.5.1 - Captain

Michel ASSELINE, born May 5th 1944 in Paris (75)

* Certificates and licences :

Airline pilot's licence obtained on June 25th 1969,
Licence valid till November 30th 1988,
Last medical check-up on May 24th 1988 performed by the Air
France Crew Medical Examination Center (CEMPN).

* Qualifications :

Airline pilot instructor's qualification obtained in 1979
Type qualifications : Caravelle SE 210 ; Boeing 707, 727, 737 ;
Airbus A 300, A 310
Airbus A 320 qualification delivered March 11th 1988

Remark : the A 320 course followed by Michel Asseline was performed in accordance with a special program for the members on the pilot's executive staff within Air France participating in placing the A 320 into in-service operation.

The proposed program, personalized to suit the role of each person within the management team, was considered acceptable by the administration provided that flight training was added, and this was in fact performed.

The assessment sheets show a very satisfactory level.

* Experience :

Total flight hours : 10,463 (end of May)
on A 320 : 138 hours

* Aeronautical career :

1962 : Admitted by competitive examination to the National Civil Aviation School (ENAC)

Theoretical and practical training from autumn 1962 to 1966.

June 1966 to February 1967 : trainee at Air France

March 1967 : engaged by Air France as copilot on Caravelle SE 210.

May 1968 to August 1969 : military service in the air force, final ranking second lieutenant (reserve lieutenant)

September 1969 : returned to Air France as copilot on Caravelle then on Boeing 707

May 1979 : named as Captain on Caravelle then airline instructor on Caravelle then on Boeing 727.

December 1982 : promoted to managerial level during the putting into service of the Boeing 737 piloted by two crew members

From January 1985 to November 1987 : Airbus A 300 and A 310 qualifications

Promoted to a higher level with :

Responsibility for the preparation of the choices regarding flight simulators (B 737 and A 320 project) ; to this end, flew approximately 150 hours on the A 320 simulator at Aeroformation and Thomson.

Technical missions related to training of pilots (computer-assisted teaching, company policy related to training).

December 1987 : promoted to Head of A 320 training subdivision with responsibility for :

- development of type qualification, participation in the establishment of the aircraft utilization method and training (in cooperation with the manufacturer) of the first crews,
 - airline aircraft acceptance flights (including F-GFKC).
- * Flying activities in the last 48 hours before the accident :
ferrying of F-GFKC on Friday morning June 24th then flight as observer on an Airbus Industrie A 320 to supervise the training given to Air France trainees.
- * Previous air accidents : none.

1.5.2. First Officer

Pierre MAZIERES, born January 12th 1943 in Castelnaudary (11)

* Certificates and Licences :

Airline pilot's licence obtained on August 28th 1969
Licence valid till September 30th 1988
Last medical check-up March 14th 1988 with Air France CEMPN.

* Qualifications :

Airline pilot instructor's qualification obtained in 1982.
Type qualification : Caravelle SE210 ; Boeing 707, 737
A 320 qualification obtained March 29th 1988.

Remark : A 320 course performed in accordance with the standard Aeroformation program approved by the DGAC ; the resulting assessment sheets showed a very satisfactory level.

* Experience :

Total flight hours : 10,853 (end of May 1988)
on A 320 : 44 hours.

* Aeronautical career :

1962 : Admitted by competitive examination to the National Civil Aviation School (same year as Michel Asseline).

Theoretical and practical training at ENAC from autumn 1962 to 1968.

Training delayed in comparison with Michel Asseline following a car accident.

December 1969 : engaged as copilot by Air France.

1972 : copilot on Boeing 707.

July 1980 : Promoted to Captain on Boeing 727.

December 1982 : Promoted to instructor on Boeing 727 then Boeing 737 in March 1983.

January 1986 : Promoted to managerial level on Boeing 737.

March 25th 1988 : Promoted to a higher position to participate in the placing into service of the A 320.

* Flying activities in the last 48 hours before the accident : none.

* Previous air accidents : none.

1.5.3 Cabin attendants

Jean Claude BARGETON, born May 15th 1948 was performing the purser's functions and was on the seat located beside the left forward door.

Safety-rescue certificate No. 5861 obtained on June 23rd 1972.

Last medical check-up : June 15th 1988.

A 320 specialization certificate : April 14th 1988.

Total flight hours : 8969 hours

On A 320 : 11h 23.

Last flight on A 320 : June 25th 1988.

Chantal de CHALONGE, born March 9th 1951, occupied, in the cabin, seat 12 R level with the wing emergency exit.

Safety-rescue certificate No. 6741 obtained on July 16th 1973.

Last medical check-up : September 10th 1987.

A 320 specialization certificate : April 14th 1988.

Total flight hours : 6784
On A 320 : 21h 50

Last flight : June 25th 1988 on Boeing 727
June 23th 1988 on A 320.

Previous events : was cabin attendant on the A 300 highjacked at Brindisi.

Muriel DAGER, born June 3rd 1957, occupied a crew seat on the left in the aft galley.

Safety-rescue certificate No. 9648 obtained on May 16th 1972.

Last medical check-up : September 11th 1987.

A 320 specialization certificate : April 15th 1988.

Total flight hours : 3022
On A 320 : 22h 50
Last flight A 320 : June 25th 1988.

Bruno PICHOT, born February 23rd 1951, occupied the seat on the right level with the aft galley.

Safety-rescue certificate No. 7085 obtained September 20th 1973.

Last medical check-up : January 7th 1988.

A 320 specialization certificate : April 28th 1988.

Total flight hours : 8223
On A 320 : 20h 20
Last flight on A 320 : June 24th 1988.

Previous accidents :

Was cabin attendant during the evacuation of damaged Boeing 747 at Bombay (India) in 1975 ; the aircraft was totally destroyed by fire during this accident.

1.6 - AIRCRAFT INFORMATIONOwner and Operator :

Owner : DURUS VERWALTUNGSGESELLSCHAFT MBH Co MOBILIEN KG (1).

Operator : AIR FRANCE

- Airframe :

- . Manufacturer : AIRBUS INDUSTRIE
- . Type : AIRBUS A 320-100
- . MSN : 009

This aircraft obtained Airworthiness Certificate No. 109 099 and noise certificate No. 109 099 on June 22nd 1988.

It was delivered on June 24th 1988.

- . total flight hours : 22h 30
- . number of operating cycles : 18

- Engines

- . Manufacturer : CFM International - engine manufactured in cooperation by General Electric (USA) and SNECMA (France)
- . Type CFMI 56-5A1
 - engine No. 1 (left) : Serial No. 731 122
 - engine No. 2 (right) : Serial No. 731 120
- . delivered to Airbus Industrie on October 6th 1987
- . operating hours : S/N 731122 : 27h 20
S/N 731120 : 33h 45.

- Information given on engineering reports

Due to the recent delivery date, the remarks made by the crews are limited. The significant reports are as follows :

- June 25th and 26th 1988, it was reported that the flight management and guidance computer (FMGC) No. 2 did not have the same data base as computer No. 1,
- June 26th 1988, altimeter setting changed to a new incorrect value during a DMC (display management computer) transfer.
- June 25th 1988, occurrences of a warning related to a nose wheel steering valve (this warning can be heard in the CVR before the GPWS (2) "too low, terrain" message).

- (1) under a leasing contract with Air France
- (2) GPWS : Ground Proximity Warning System (warning system of proximity to ground, based on radio-altitude).

These anomalies had not been corrected before June 26th 1988. After an in-depth study, the Commission concluded that none of these had played a role in the accident (note that the second anomaly did not recur).

Weight and balance

There were 6 crew members and 130 passengers, 2 of the passengers (air hostesses) being in the cockpit, for a total number of 153 passenger seats available in the cabin.

The seats had not been attributed because it was a charter flight ; consequently, the Commission could not determine with exactitude the position of each passenger in the cabin.

The weight and balance on take-off calculated after the accident were :

- weight : 59,635 kg
- CG : 30.7 %

The weight and CG calculated before the flight were marked in the logbook as being :

- weight : 59,040 kg
- CG : 25.8 %

This difference is due to several consecutive errors :

- At Paris-Charles de Gaulle, on the balance chart, 3 cabin attendants were given instead of 4, leading to an error in weight (- 80 kg) and index (-1).
- Then, in Mulhouse, the list of passengers, completed by a last minute change, mentioned only 126 passengers (respectively 110 and 16) instead of 130, i.e. an error of 300 kg.
- The aircraft tool kit, weighing 215 kg, and located in the cargo compartment, had been forgotten.
- In the balance calculation, a scale error had been made in reading the graph used to determine the influence of the weight of the passengers.

This last error was in part compensated for by those made in weight and mentioned above and by the fact that the last minute change had not led to a correction of the CG.

1.7 - METEOROLOGICAL INFORMATION

1.7.1 - General situation

At high altitude, there was a depression above Germany giving a weak north-easterly to northerly flow on its western side.

In the lower levels of the atmosphere, there was a weak gradient area with, over the Alsacian plain, sky covered by 6 to 8/8 stratocumulus plus locally 1 to 3/8 cumulus and a northerly wind of 5 to 10 kt.

1.7.2 - Conditions over flight area

The meteorological center of Basle-Mulhouse, 10 nautical miles from the accident, observed the following conditions :

- at 12h20 : Wind : 010°/6 kt
 Visibility : 8 km
 Cloud : 1/8 Cu at 780 m and 7/8 Sc at 1500 m
 Temperature : 20°C
 Dew point : 13°C
 QNH : 1013 hPa
 NOSIG
- at 12h50 : Wind : 330°/6 kt
 Visibility : 8 km
 Cloud : 1/8 Cu at 780 m and 7/8 Sc at 1500 m
 Temperature : 21°C
 Dew point : 14°C
 QNH : 1014 hPa

At 12h 41, the Mulhouse-Habsheim controller transmitted the reference pressure by radio to the A 320 pilot before the flyover was made :

- QNH : 1012 hPa
- QFE : 984 hPa

After the accident, the controller reported to the investigators that wind speed was lower than 5 kt.

The study of the video tape on which the complete flyover of the A 320 was recorded, from 160° to 340° in a westward sense, showed that the sky was covered : the stratocumulus layer was sufficiently thin for the resulting luminosity to cast a very clear shadow of the aircraft during the lowest part of this overflight.

1.8 - AIDS TO NAVIGATION

Because visual landmarks were used for the flight between the Basle-Mulhouse and the Mulhouse-Habsheim aerodromes and because of the absence of radioelectrical facilities at Habsheim, the navigation aids played no part in the accident.

1.9 - COMMUNICATIONS

The transcriptions of the radio communications between the aircraft, ground control and the Basle-Mulhouse control tower, then the Mulhouse-Habsheim control tower, were made and are given in the appendix.

Before take-off from Basle-Mulhouse, the First Officer requested an altitude of 1000 feet agl for the transit to Mulhouse-Habsheim where the two flyovers were to be made.

At the same time, he also requested control clearance for the remainder of the flight to Hericourt.

After reception of the 2000 feet QNH transfer flight clearance, he specified that he would make a first low-altitude flight heading North then a second one heading South.

Then, in contact with the Habsheim tower, he specified "we are coming into view" and "going in for the low-altitude, low speed flyover".

The controller then gave the QNH and the QFE.

The First Officer acknowledged reception at 12h 44 mn 31s, and this was the last radio transmission.

1.10 - AERODROME INFORMATION

The accident occurred at the northern limit of the Mulhouse-Habsheim aerodrome. The aerodrome is located 10 nautical miles north-north-west of the Basle-Mulhouse airport.

The Mulhouse-Habsheim aerodrome (see aerodrome chart in the appendix) has two sets of two parallel runways, none of which is capable of receiving an A 320 mainly due to the runway strength :

- one, oriented north-east/south-west (024° - 204°) has a 1000 m by 20 m hard runway and a grass strip,
- the other, oriented north-north-west/south-south-east (164° - 344°) comprises two grass strips without clearance to the north-north-west, because they are immediately bordered by a forest of oak and birch. It was runway 34 R, one of these two grass runways, 640 m long, which was acting as the base for the show, the visitors being massed to the west of these strips, along the front of the hangars.

The aerodrome which is located 6 km to the east of the city of Mulhouse (coordinates : Lat. 47.44.17 N - Long. 07.25.58 E), is bordered on the west by a motorway, a high-voltage transmission line and a railway line, on the north and the east by the forest. It stands out clearly from its surroundings.

Its reference altitude is 240 m (787 feet) which corresponds to a difference in standard pressure of 28 hPa, with respect to sea level. The thresholds of strips 16-34 which served as the A 320 demonstration axis are at an altitude of 239 m for threshold 34 and 238 m for threshold 16.

The Hardt forest starts immediately after the road which borders the end of runway 34.

The distance between the end of runway 34 R and the forest is 60 m and the average height of the trees is 12 m.

The aerodrome has a 12 m-high control tower located in the angle formed by the two sets of two runways. It was operating on the day of the accident and its equipment was in good working order. Its orthogonal projection on axis 16-34 is located 250 m from the end of runway 34.

The Habsheim control tower barometers were checked by the National Meteorological service and showed no malfunction of the instruments, the difference with respect to the reference barometer being lower than 0.5 hPa, within the tolerances for this type of instrument.

1.11 - FLIGHT RECORDERS

In compliance with the regulations in force, the A 320 F-GFKC was equipped with a cockpit voice recorder (CVR) and a digital flight data recorder (DFDR). These two recorders, made by Fairchild, were found in the wreckage of the aircraft on their mounts located in the aft section of the fuselage, and were transferred to Paris in the evening of June 26th for read-out.

1.11.1 - Read-out of recorders

1.11.1.1 - C.V.R. (Fairchild A100)

The C.V.R was opened and the first reading of the tape made during the night from the 26th to 27th June on the facilities of the French Accident Investigation Bureau (BEA).

The transcription was then made with assistance from the pilots.

To obtain an accurate chronology, the tape feed speed was initially set using the 400 Hz frequency of the on-board electrical power supply which appeared in the recorded spectrum. Then, the recordings of the radio transmissions were correlated with those of the air traffic control frequencies (the latter included a time track).

The part of the recording corresponding to the end of the flight (from the descent through 200 feet agl) was studied by spectral analysis : the continuous recording of frequencies has permitted a very accurate chronology of the end of the flight to be obtained with an error of less than 0.1 of a second, in using events with precise time and frequency signatures (synthetic voice of the radio-altimeter, characteristic noises, voices, etc.).

The spectral analysis also permitted the engine speeds to be determined, their characteristic frequencies being recorded on the CVR via the cockpit microphones. It also enabled correlation to be made with a video tape of the accident, the sound track of which was submitted to the same type of analysis.

1.11.1.2 - DFDR (Fairchild F 800)

The DFDR was read out by the Brétigny sur Orge Flight Test Center (CEV) during the night from the 26th to the 27th of June by designated persons from this establishment.

The normal validation work made by the BEA on the first listing supplied by CEV revealed that, in spite of the care taken during reading, certain data had been misread. The anomalies observed concerned :

- incorrect reading of the information during a period of 8 seconds (starting 17 seconds before the end of the recording and 10 before the engine throttle levers were placed in the go-around position) 4 seconds of which had been rejected by the reader checking program and therefore were not printed,

- certain errors in the A 320 parameter reproduction software used by the CEV (inversion of the sign for the positions of the right and left ailerons for example).

The initially incorrect reproduction of the data was no doubt due to an interruption of contact between the reading head and the recorded tape, caused by a fold in the tape and/or by dust. The following readings, made after cleaning and smoothing out of the tape, permitted correct reproduction of all data.

A bit by bit analysis of the recording for the last part of the flight confirmed the validity of the data obtained.

The parameter reproduction software errors (signs, constant values, etc.) were easily corrected.

1.11.2 - Operation of recorders

The operation of the recorders was perfectly correct throughout the whole flight itself, i.e. until first impact with the trees.

As concerns the CVR, the conversations and aural warnings were correctly recorded as well as all the noises in the cockpit.

As concerns the DFDR, all parameters were correctly recorded.

Lastly, the consistency of the data obtained from the reading out of the CVR and the DFDR and certain outside media (photographs, video tapes, etc.) can be described as excellent.

After the first impact with the trees, the CVR continued to operate for around 1.5 seconds and then stopped. The DFDR continued to operate for around one second then gave incoherent data for around two seconds. This is followed by the data of a previous flight. The exact moment when the aircraft came to rest cannot be accurately specified. The only cause that can explain this almost simultaneous shutdown of the two recorders is the breaking under tension of their power supply cables located in the rear section of the fuselage. The inspection of the tail cone where the recorders are installed showed that the break of the power supply cables could not have occurred in this section of the aircraft which suffered little damage ; it is probable that the break occurred forward of this area, doubtless in the landing gear well, which is the most exposed area for the bundle of wires considered. However, this assumption could not be checked due to the condition of the wreckage.

The other causes liable to result in shutdown of these recorders were studied, the most probable being simultaneous cut off of the electrical power supply to the two recorders either by shedding or by ejection from their mounts. These assumptions could not be retained in this case as :

- The busbars of each of the recorders can not be simultaneously shed when the AC generators operate correctly, as was the case judging by the engine speeds at the time when the recorders stopped, as determined by the spectral analysis of the video recording sound track,
- The recorders were found on their mounts.

1.11.3 - Read-out of the conversations and the aural warnings (CVR) :

The transcription of the CVR recordings is given in the appendix ; it starts with the start-up of the engines at Basle-Mulhouse and stops at the end of the recording (shortly after the first impacts with the trees). The start of the recording, of a total length of 30mn, concerns the arrival of the previous flight from Paris-Charles de Gaulle.

The CVR recording is very easy to follow especially because the crew were working with headsets.

The following points can be noted concerning the flight sequence :

- On start of taxiing at 12h 29, the First Officer requested the Captain to confirm the items planned for the overflights at Habsheim. The Captain indicated that he would make the first demonstration in Flap configuration 3, landing gear extended, at 100 feet, with maximum angle of attack, alpha floor function (1) disengaged, First Officer adjusting thrust to maintain flight-level ; when requested by the Captain, the First Officer was to select maximum engine power, whilst the Captain carried out a climbing turn. The second overflight was then scheduled, also at 100 feet, with the First Officer at the controls, in clean configuration and at high speed (340 knots).
- The Captain then outlined the programme to the Purser and the First Officer specified that it would be best to remain seated during the demonstration (passengers and crew strapped in).
- Take-off was made at 12h 41, the autothrottle was disengaged as soon as the landing gear had been retracted and flaps placed in position 1.
- Radio contact was established with the Habsheim tower at 12h 44 and F-GFKC was cleared to make its overflight. During the descent, the crew selected the altimeter setting for Habsheim (QFE 984 hPa), then extended the landing gear and the flaps (position 2 then 3).
- The radio altimeter called 200 feet, then 100 feet at the exact moment when the First Officer told the Captain that the aircraft had reached this height.
- The radio altimeter continued to announce the heights (40 then 50 then 40 feet). Between 50 and 40 feet, the Captain confirmed the disengagement of the autothrottle. The First Officer drew the Captain's attention to the presence of pylons ahead.
- Full application of power (throttle-levers forward) was made by the Captain immediately before the radio altimeter announced 30 feet three times consecutively.

Next, the increase in engine speed can be clearly heard before the noise of the impacts with the trees which progressively covers that of the engines.

1.11.4 - Read-out of the parameters recorded on the DFDR (see appendix)

The number of parameters (200) recorded on the A 320 - 141 of which are discrete (yes/no) - and the quality of the recording permitted the flight sequence to be reconstructed with high accuracy up to the moment of impact with the trees.

(1) see paragraph 1.16.1.2

Take-off was made at 12h 41, heading 155°, and the aircraft left the ground at an IAS of 153kt. Turn was started in the second that followed. Four seconds later, roll control passed through a maximum and at this time the radio altimeter indicated 76 feet. The bank angle was then stabilized at 34° approx. The right turn was held for one minute until heading 010 was reached, at the end of the turn the aircraft entered level flight at 1900 feet QNH (approximately 900 to 1000 feet above the ground) at a speed of 200 kt. Progressively, the heading changed to the left to 335°/340°. At 12h 43mn 44s, the aircraft, which had reached 2000 feet QNH (1) started its descent. Descent rate was initially low, 300 feet per minute. At 12h 44mn 14s, the engines were set to idle, the speed, which was 200kt at this time, slowed by approximately 1kt per second. Three seconds later, landing gear extension was commanded and a further ten seconds later, the flaps, which had remained in position 1, extended to position 2. At 12h 44mn 45s, the flaps were extended to position 3, the aircraft descended through 500 feet with a speed of 177kt, mean heading still 334, which was maintained until 90 feet in the descent to Habsheim.

At 12h 45mn 06s, aircraft speed was 155kt, as it passed the radio-altimeter height of 200 feet. The barometric altitude decreased continuously, the radio-altimeter height oscillated around 200 feet between 12h 45mn 06s and 12h 45mn 09s (the terrain over which the aircraft was flying was not flat).

Between 12h 45mn 15s and 12h 45mn 23s, the aircraft made a gentle right turn to line up with runway 34 R, maximum bank angle reached was 13° and heading coming out of the turn was 344°. The speed dropped from 149 to 141kt and the height decreased from 90 to 46 feet. A fluctuation in the radio altimeter height can be seen during this alignment manoeuvre (32 feet at 12h 45mn 18s and 24 feet at 12h 45mn 19s) corresponding to flight over a clump of trees located in front of the runway. Before and after this fluctuation, there is perfect agreement between the readings of the radio altimeter and those of the barometric altimeter.

At 12h 45mn 26s, the aircraft reached 40 feet, still descending, speed was 132kt, still falling, the engines were still at idle (29% of N1). At this time, the pilot started a flare to level off close to the ground, the side stick pitch movements being of low amplitude (on average, 4° nose up).

The lowest points in the flight path were around 30 feet in height : between 12h 45mn 32s and 12h 45mn 39s, the radio altimeter indicated 32, 32, 32, 32, 30, 30, 24 and 34 feet (one value per second). During this level flight :

- The side stick, previously at 4° nose up until 12h 45mn 30s, was brought to and held at 6/7° nose up until 12h 45mn 36s.

(1) The QNH altitude readings are the result of a calculation. The one recorded on the DFDR corresponding to altitude pressures set at 1013.2 hPa.

- The throttle levers were placed in the TOGA (take-off/Go-around) detent between 12h 45mn 34s and 12h 45mn 35s. At 12h 45mn 34s speed was 122kt and angle of attack 13°. At 12h 45mn 35s, the fuel-flow of engine 1 (recorded at the end of each second on the DFDR) had already increased (from 406 to 682kg/h), its speed N2 had varied from 71 to 72%. The increase in power on the two engines was uniform and at 12h 45mn 39s the N1 speeds were respectively 83 and 84 %.

- From 12h 45mn 35s, the angle of attack reached values of 14 and 15°.

- At 12h 45mn 37s, the stick was set nose-up to 13° then to full nose-up in the two seconds which followed.

Between 12h 45mn 39s and 12h 45mn 40s, the aircraft touched the trees ; as shown by a decrease in longitudinal acceleration.

After 12h 45mn 40s, the data recorded on the DFDR is incoherent for approximately two seconds, and this followed by the data relevant to the flight preceding the one in which the accident occurred (closed loop operation of the flight data recorder).

To sum up, the flight was completely reconstructed up to impact with the trees. No particular comments need to be made on the initial flight phase. The final flight phase can be summarised as follows, taking "t" as the time reference 12h 45mn 39s :

- . t-25 sec Aircraft passes 100 feet in descent at a speed of 151kt
- . t-17 sec Aircraft passes 50 feet at a speed of 141kt
- . t-13 sec Aircraft passes 40 feet at a speed of 132kt
- . t-7 sec Aircraft reaches 32 feet at a speed of 123 kt
- . t-6 sec Aircraft is still at 32 feet at a speed of 122kt, the throttles are still in idle position
- . t-4 sec The throttles have been brought to the TOGA detent, the N1 and the fuel flow rates start to increase
- . t-1 sec The stick is in full nose-up position, speed is 112kt, engine N1s are 67%
- . t sec Stick is still in full nose-up position, speed is 114kt, engine N1s are 83 % and 84 %.
- . t + 1 sec The aircraft has already touched the trees

The work conducted by the Commission to verify that the aircraft response to the commands given by the crew, through the flight and engine controls, showed no anomalies, and is covered by paragraph 1.16 below.

1.12 - WRECKAGE (see sketch in appendix)

1.12.1 - Flight path

A forest of young oak and birch of an average height of 12m and a base diameter of 20 to 30 cm is located at approximately 60 meters from the end of runway 34 R.

The A 320 hit the top of these trees at the edge of the forest with the rear section of the fuselage and the horizontal stabilizer. Due to the engine thrust, the trees are broken in the opposite direction to that of the aircraft's movement.

The aircraft touched the trees in line with the runway centreline. Its path in the forest was practically straight and always in line with the runway centreline. The wreckage itself was located on the extension of this centreline.

Fifty meters beyond the edge of the forest, the marks left by the landing gear and the engines can be seen in the tops of the trees. Further on still, the wing leading edges cut off the tops of the trees at lower and lower levels as the aircraft sank into the forest. Judging by the way the tops of the trees were cut off, the aircraft was banked in flight slightly to the right.

The evacuation of the various elements of the wreckage (especially for the investigation) required that these trees be felled. The heights of fracture were measured and plotted on a dimensioned drawing. This enabled an accurate path of the entry of the aircraft into the trees to be plotted.

1.12.2 - Wreckage

The wreckage was grouped together. Its rear end was found 270 m from the road which separates the runway from the forest.

Upstream, the first large pieces of wreckage were found 230 m from the road : the tip of the right wing with a portion of aileron and, slightly further away, a portion of slat.

On approaching the wreckage, several pieces of flight control surface (slats and flaps, ailerons), and of empennage, cowlings and engine accessories were found together with small pieces of skin.

The main part of the wreckage was surrounded by a jumble of torn and broken trees. The aircraft was largely destroyed by the fire which followed the accident : the fuselage was completely burnt out, except for the empennage and the zone located aft of the pressurized bulkhead where the recorders were found intact.

The right wing, broken into several portions, was also destroyed by the fire.

The right engine, torn from its pylon, lay slightly to the rear of the wing, with the air intake facing towards the tail of the aircraft. The air intake sound-proofing panels were wrapped around the fan vanes which suffered practically no damage from the accident.

The position of the variable stator vanes (VSV) corresponded to a low engine speed. The low pressure compressor bleed valves (VBV) that were visible were damaged.

The left wing was complete and remained attached to the fuselage.

The leading edge had been crushed in by the trunks of the trees and many branches had stuck there.

On the left engine, the position of the VSVs also corresponded to a low engine speed, the visible VBVs were also damaged. The expert investigation of the engines described in paragraph 1.16 permitted these points to be more accurately defined.

Slightly forward and to the right of the aircraft, many trees were burnt indicating that burning fuel was projected forwards from the right wing.

The examination of the trim screw showed that the trimmable horizontal stabilizer (THS) was set to approximately 4.5° which is consistent with the DFDR indications (last recorded value was 4.4°).

1.13 - MEDICAL AND PATHOLOGICAL INFORMATION

1.13.1 - Pilots

a - Study of medical files

The examination of the medical files of the Crew Medical Examination Centres (CEMPN) revealed no medical evidence which could have influenced the accident. The two pilots had successfully passed their routine medical check-ups every six months since 1962.

b - Injuries caused by the accident

Michel ASSELINE

- Various bruises with no signs of bone fracture visible on the X-rays. Bruising of the collarbone (shoulder harness in place),
- Inhalation of smoke and emotional shock,
- Kept in hospital one day at Mulhouse,
- Absence from work from June 26th 1988 to end of November 1988.

Pierre MAZIERES

- Injuries to the head, without true loss of consciousness, but with clouding of vision, with no signs of bone fracture visible on the X-rays
- Forehead wound (stitched in hospital)
- Bruising of both collarbones (shoulder harness in place),
- Kept in hospital for one day at Mulhouse,
- Returned to hospital for 10 days in August 1988,
- Absence from work from June 26th 1988 to end of November 1988.

c - Timetable before the accident

Michel ASSELINE

The day before the accident, the Captain made training flights on the A 320 with three trainees. He went home around 17h00 UTC (19h00 local time) and spent a normal night and slept well.

On June 26th 1988, he had breakfast around 4h00 (6h00 local) before leaving for Roissy-Charles de Gaulle, where he arrived around 6h15 (8h15 local) for the briefing and flight preparation. During a reception with the Authorities and the reporters at Basle-Mulhouse airport, before the demonstration flight, he drank a fruit juice and ate nothing.

Pierre MAZIERES

The day before the accident, he led a normal life in Paris spent a good night and slept well.

On June 26th 1988 on the day of the accident, he got up around 3h00 (5h00 local) and had a full breakfast at home. He arrived at Roissy-Charles de Gaulle around 5h30 (7h30 local) then prepared his flight following another light breakfast.

During the Basle-Mulhouse reception, he drank a fruit juice and ate a piece of cake.

d - Alcohol measurement

An alcohol level measurement was made on the two pilots by the Police by means of a breathalyser. As the tests were negative, blood sample alcohol measurements were not performed.

1.13.2 - Cabin attendants

The 4 cabin attendants suffered from various bruises, without bone injuries, and psychological traumas justifying grounding.

1.13.3 - Passengers

- . 110 persons passed through the screening centre and the hospitals (Basle included). Amongst these passengers, 76 were allowed to go home and 34 were hospitalized.
- . 12 days after the accident, 8 passengers were still in hospital.
- . 42 persons were given leave from work or granted certificates of temporary inability to work for 7 days or more.
- . 41 persons suffered from facial or cerebral cranial traumatism with face injuries, broken noses, nose bleeding. These injuries were caused by impact with the seat located in front of the passenger during the accident.
- . Other injuries and pathological facts included the following :
 - 2 broken upper arms
 - 1 broken thigh-bone
 - 6 bruised rib cages and broken ribs
 - 2 dislocated shoulders
 - 2 fractures of the spine by compression
 - 8 cases of immediate and marked emotional shocks.
- . The traumatic injuries were, for the most part, caused by the evacuation (escapes slides damaged by the trees or badly deployed because of obstacles, rapid evacuation, with the passengers piling on top of each other, and violent contact with the ground).

The three deaths were not caused by acceleration effects during impacts but by the fire which also caused burns on four other passengers (one of them suffered 23% burns).

1.14 - FIRE

1.14.1 - Development of the fire

During the impacts with the trees, the right wing was torn off, the fuel was projected forwards by inertia and immediately ignited causing a very violent fire, from the moment when the aircraft stopped, to the right and forward of the fuselage.

Passengers (see paragraph 1.15) also report that fire broke out on the left of the fuselage, level with the wings, and penetrated into the left section of the cabin through the broken windows at the level of rows 8 and 9, and in the right section through the holes in the floor between rows 10 and 15. The fire spread throughout the cabin.

Later on, fuel flowed out of the left wing and fed the fire in the fuselage.

Only the left wing and the tail of the aircraft (where the flight recorders were located) were not destroyed by the fire, mainly due to the intervention of the firemen.

1.14.2 - Fire fighting

Six firemen and 2 vehicles were standing by at the Basle-Mulhouse aerodrome to cover the airshow.

They drove immediately to the place of the accident to fight the fire.

The alert was given immediately and, 10 minutes later, the first group of 8 fire fighting vehicles from Saint Louis, Ottmarsheim, Thann, Altkirch and Colmar arrived at the accident site.

Note that only small vehicles were able to reach the wreckage, the other vehicles were blocked by the trees and this considerably hindered the fire fighting.

1.15 - SURVIVAL ASPECTS - EVACUATION

1.15.1 - Evacuation sequence (1)

Before the Paris-Charles de Gaulle/Basle-Mulhouse flight, the cabin attendants made the terminal turnaround inspection without detecting defects other than a broken mirror in the aft galley. This mirror permits the cabin attendant to observe the cabin from his seat.

During the Basle-Mulhouse line stop, a tetraplegic boy was installed in seat 4D (aisle), reserved for handicapped persons, then, for commercial reasons on the request of his family, in seat 4F (window).

After the take-off, the signs asking the passengers and the cabin attendants to keep their seat belts attached were illuminated as planned.

During the impacts with the trees and the ground, most of the passengers hit their heads on the seat in front of them causing many facial injuries and dizziness.

At the aft galley, objects fell onto the cabin attendants.

Before the aircraft came to rest, all the lights went out ; it seems that the emergency lighting, apart from the exit signs, did not come on. Also, breakages must have occurred in the lower right section of the fuselage forward of the wing because, as soon as the aircraft came to rest, passengers saw flames and smoke coming out of the floor on the right-hand side of fuselage between rows 10 and 15.

Several seconds at most after the aircraft came to rest, the fire entered the cabin through the broken windows on the left side at the level of rows 8 and 9.

Also, several passengers reported short circuits with sparks around the forward galley and smoke coming from this area.

As soon as the aircraft came to rest, the stewards stationed at the forward and aft doors, seeing the fire on the right of the aircraft, opened the left doors.

The Captain declared that he made several attempts to trigger the evacuation signal ; but it seems that this signal did not work as nobody in the cabin heard it.

(1) This sequence of events is essentially based on reports made by the cabin attendants and passengers.

A passenger stated that he had wanted to open the left wing emergency exit but could not reach it. The commission observed that the opening of this exit, without prior check, would have been very dangerous as fire was raging around the left wing level.

The left forward door was blocked by branches after it had started to open correctly. The escape slide started to deploy partly outside and partly inside the cabin.

The purser, with the help of at least one passenger and an air hostess from another airline (who was in the cockpit as a passenger during the flight), pushed the door. The door opened suddenly and the purser and the passenger fell out of the aircraft and were covered by the escape slide.

The passengers started to panic and push in the front part of the cabin.

The passenger hostess mentioned previously then started to evacuate the passengers, but the first ones were blocked by branches in the escape slide. The other passengers jumped out beside the escape slide but they very quickly piled up on top of each other again due to the branches. The hostess then stopped evacuation for a short while so that the passengers who had already jumped had time to extricate themselves. She thinks that she was helped by another person (unidentified).

Meanwhile, on the outside, the purser with the help of another air hostess, also passenger in the cockpit and who was no doubt left during the pushing, tore away the branches from across the escape slide to free the blocked passengers.

After a certain time, the first passenger hostess herself left the aircraft suffering from the effects of the smoke.

The hostess stationed in the center of the aircraft at 12D was pushed into the aisle by the passenger in 12F who was seriously burnt, then was carried forwards whilst at the same time helping a passenger whose clothes were on fire.

She arrived at the left forward door (1G), no doubt after the evacuation of the previous hostess, and took her place. After the evacuation of the last persons to arrive at this door, she called into the cabin to find out if anyone was still there but did not get any reply ; by this time, the smoke, very thick, and flames made any visual inspection impossible.

On the order of the Captain, who had just evacuated the injured First Officer, she then left the aircraft.

The Captain then returned to the cockpit to get an anti-smoke mask with the intention of going through the cabin, but in turn had to leave, before he could don the equipment, suffering from the effects of the fumes.

Note that the cabin attendants either were not able to use the anti-smoke masks during the evacuation or did not think of doing so. They were, in fact, more occupied in opening the doors as quickly as possible so as to speed up passenger evacuation.

The left aft door was opened without any problems and the escape slide was correctly deployed. The steward ordered the passengers to come towards him to evacuate and at the same time reassured them verbally. This, combined with the absence of smoke at the rear of the cabin, certainly contributed towards the good evacuation via this door.

After several passengers had used the escape slide it was punctured on the branches. The steward asked his colleague to descend to help to receive the passengers.

Evacuation continued without panic with spontaneous help from one passenger, especially for the evacuation of an elderly person who had difficulty in moving.

After the last passengers had left the aircraft, the hostess returned to go through the cabin but the flames and smoke had reached the galley ; she was only able to shout out in the direction of the cabin.

During the evacuation, the stewards and hostesses could not see what was happening at the other end of the aircraft due to the fire around the left wing. Therefore, after the end of evacuation via their door, they went round the wing towards the front or the rear to see if they could be of any help at the other door.

It has not been possible to determine the time it took to evacuate the survivors.

All passengers were able to leave the aircraft, except three :

- the young handicapped boy in seat 4F who seems to have remained in his seat ;
- a little girl located at 8C who, according to her young brother (carried away by the flow of the other passengers), had not been able to open her seat belt and was blocked by the back of her seat which was tilted over onto her ;
- a woman travelling in seat 10B, who according to her husband, had reached the left forward door ; as her body was found near to that of the little girl, we can reasonably assume that she went back into the cabin to help the little girl and was overcome by the fumes.

It appears that some of the safety equipment proved to be deficient or inoperative :

- . As we have seen above, before the aircraft came to rest, the normal lighting went off and the emergency lighting did not come on, due to a design error in its automatic illumination program,
- . There was no evacuation signal in spite of several attempts made by the Captain ; this fault is doubtless related to the other observed electrical problems,
- . When the aircraft came to rest, the purser wished to broadcast a message via the public address but could not find the handset which, apparently, had been torn from its support, maybe due to the fragility of this support and of the attachment of the electrical lead.

One doctor, one ambulance and 10 first-aid workers were present at the aerodrome for the air show. As soon as the accident occurred, they alerted both the fire brigade and the hospital emergency services (the various services had been informed of the air show and had emergency services ready in accordance with the usual arrangements for this type of meeting). They arrived on the scene of the accident and participated in the first examination of the injured and gave first aid while awaiting reinforcements from Mulhouse. The setting-up, 25 minutes after the accident, of an ambulance evacuation circuit and the organization of the examination centre were performed under the guidance of the fire brigade doctor. On the whole, the hospitalization was achieved without great difficulty, due to the minor character of the injuries, the small number of persons injured, the geographical location of the accident, near to a large town, the good cooperation between the medical emergency teams and the good operation of the hospital emergency plan.

Also, around twenty passengers stated that they got home or went to the hospital by thumbing a lift on the nearby road without passing via the emergency station. Because of this, they were initially reported missing, which complicated the task of the rescuers.

1.15.2 - Investigation

a) Definition of the questionnaire

Due to the conditions of the accident (smoke, workload, etc.), the cabin attendants could not give in their evidence a complete and exact description of the evacuation procedure. Consequently, the Investigation Commission decided to send a questionnaire to each passenger with the aim of clarifying the following points :

- 1) the conditions relevant to the opening of the left forward door,
- 2) the entry of smoke and fire into the cabin (as it had only been established that smoke had very quickly entered the cabin and that the hair of one woman passenger in row 12 had caught fire),
- 3) the injuries sustained during the impacts with the trees and the ground, then during evacuation,
- 4) the position of each passenger in the cabin and the emergency exit through which he left the aircraft,
- 5) and more generally, the evacuation procedure from the point of view of the passengers and their impressions.

The Commission decided to avoid all technical terms and to use, as far as possible, multiple choice questions ; this also facilitated the processing of the replies.

Also, at the end of the form, a general and narrative question permitted the passengers to give all their opinions.

A plan of the cabin was appended to help the passengers make their replies.

b) Results

Of the 127 questionnaires sent to the surviving passengers, the Investigation Commission received 99 replies (78%) for the most part very accurate and well thought out.

The replies to questions 1, 2 and 5 were largely covered in the previous section, 1.15.1.

The replies to question 3 are covered by paragraph 1.13.

Concerning the 4th question, it appears that the passengers correctly remembered their position in the aircraft and had left by the door nearest to their seat : the dividing line, between the passengers who left by the forward door and those who left by the aft door was located around rows 12 to 15 (there is no row 13) ; the only real exception concerns a passenger who was located in row 18 and who exited the aircraft via the front, without doubt to join his family who were seated further forward.

Also, the evidence of the passengers has permitted their individual behaviour during the evacuation to be established :

- The special character of the flight (round trip and first flight for most passengers) had several consequences :
 - . the passengers had practically no hand luggage and lost no time trying to recover it,
 - . they had been particularly attentive during the presentation of the safety cards.
- It was also confirmed that the reassuring yet firm words of the steward at the rear were of a great help for the passengers and clearly limited the panic at the rear of the aircraft.
- Also, 11 passengers clearly stated (even though the question had not been asked) that they had had difficulty in opening their seat belts and that some of them required help ; it is almost certain that this is not due to the opening mechanism but to a lack of knowledge of the system. As we have seen, this seems to be one of the reasons for the death of the young girl whose brother declared "she could not open her seat belt".

1.16 - TESTS AND RESEARCH

The main objective of the tests and investigations conducted by the Investigation Commission was to check if the sequence of flight events could have been affected by a malfunction of the aircraft, its engines or its equipment. Their main concern :

- analysis of the operation of the flight controls and verification of the conformity of aircraft F-GFKC to the definition covered by the airworthiness type certificate.
- investigation of the engines and analysis of their operation during the flight and especially during go-around.

Also, the radio-altimeter announcement sequence, which on first investigation could seem to be abnormal, was also especially studied.

1.16.1 - Analysis of the operation of the flight controls

1.16.1.1 - General

The AIRBUS A 320 is equipped with a new generation flight control system : it is the first civil transport aircraft to be equipped with digital fly-by-wire controls.

Two main characteristics distinguish a fly-by-wire control system :

- the commands given by the crew are transmitted in electrical form to the computers and are not directly transmitted to the servocontrols by mechanical means,
- the flight control computers also receive, as input data, the information delivered by the on-board sensors and can, from this, generate the optimized flight control deflection commands for each flight phase.

This second point permits an improvement in the flying qualities and reduces the pilot's workload as can be seen by the two following examples :

- the system is designed to compensate automatically for external disturbances due, for example, to turbulence : if it detects a movement of the aircraft when the pilot has not given the command, it will itself compensate for this movement.
- the system can incorporate automatic limitations preventing the aircraft from going beyond predetermined values stored in memory, for example : load factor, angle of attack or roll rate.

The result is that, unlike older aircraft, there are no one-to-one relations between the position of the controls and the position of the control surfaces.

1.16.1.2 - AIRBUS A 320 flight control laws

The Investigation Commission particularly studied the final flight phase, from the passage through 300 feet agl. On the AIRBUS A 320, in the aircraft configuration during this flight phase, the longitudinal flight control laws change in the following way during an approach (for reference, the lateral flight control laws do not change) :

- . Throughout the flight phase preceding the moment when the aircraft reaches a height of 50 feet, measured by the radio altimeters, the flight control law is the usual law designated C* : this consists in controlling the load factor around the value 1, with damping corrective terms for the angular rate of pitch and the derivative of conventional speed. The effects of the load factors and of these terms are constant for speeds lower than 150 kt.
- . During the descent phase between 50 and 30 feet, the flight control law is modified to gradually take into account (1) a longitudinal attitude term (difference between detected attitude on passing through the 50 feet agl, called reference attitude, and the actual instantaneous attitude), instead of the load-factor term.
- . On passing through the 30 feet agl, an additional command intended to simulate a conventional ground effect is introduced to supplement the previous pitch attitude control law : this command gradually brings the reference attitude (detected at 50 feet) to -2° in 8 seconds creating a nosedown pitching moment that the pilot must counter ("derotation").

If at any time, the angle of attack reaches 14.5° , the flight control law is modified and the load factor term or the attitude term (modified or not by the derotation law) is replaced by an angle of attack term (difference between measured angle of attack and 14.5° value). This flight control law ensures, in particular, an automatic protection preventing the aircraft from reaching an angle of attack greater than 17.5° to retain a sufficient margin in relation to a stall, even if the pilot holds the control in full nose-up position.

This above mentioned flight control mode, named Alpha Prot (high angle-of-attack protection) is a priority mode as soon as angle of attack reaches 14.5° . It is not a degraded mode and cannot be deactivated by the crew.

Lastly, remember that when the radio altimeter height is greater than 100 feet, power is automatically applied if the angle of attack reaches 15° . This function, called Alpha Floor, intended mainly to counteract the effect of high wind gradients during approach, can be inhibited by the crew :

(1) this occurs progressively ; the change of law is made in one second.

- . either each time an increasing angle of attack goes beyond 15° by acting on one of the instinctive disconnect pushbuttons on the throttle levers, or by disengaging the autothrottle, or by placing the throttles in the idle position.
- . or permanently by pressing, for more than 30 seconds, on one of the instinctive disconnect pushbuttons.

For the flight made on June 26th 1988, it is possible to reproduce the flight control laws which must have been effectively in operation during the approach and the flight over Habsheim aerodrome on the basis of the information recorded by the DFDR, taking same time reference "t" : 12h 45mn 39s.

- . before t-22 sec : usual C* law,
- . between t-21 sec and t-20 sec, change to pitch attitude control law (corresponding to a jump in the radio altimeter information during this time interval),
- . between t-20 sec and t-18 sec, gradual return to C* law,
- . between t-18 sec and t-4 sec, pitch attitude control law (difference with respect to measured 6° value during passage through 50 feet),
- . at t-4 sec, switching to high angle-of-attack protection law, as 14.5° was reached, this law then being maintained.

During runway flyover, since the 30 foot height was not reached before the 14.5° angle of attack, the derotation law could not have been activated. This point is confirmed by the fact that the pitch control was practically stable (6 to 7° nose-up) whereas the pitch attitude and the angle of attack increased. If the ground effect simulation law had been activated, the attitude hold and, a fortiori, its increase, would have required nose-up action on the pitch control and this is not shown on the recordings.

1.16.1.3 - Investigations carried out

The normal operation of the flight controls was never questioned by the crew of the A 320 involved in the accident. The Investigation Commission nevertheless judged that this point must be checked out in detail.

This check was carried out on the basis of flight simulations with the aim of checking if the behaviour of the aircraft F -GFKC could be considered normal during the flight made on June 26th 1988. To this end, the Commission had flight simulation tests performed on a representative ground-based simulator (1) and on the A 320 No. 3 (flights No. 260 on July 27th and No. 355 on November 14th 1988). Some of the members of the Commission themselves performed several of these tests.

Each of these means (simulator and actual aircraft) presented advantages and disadvantages vis-à-vis the required objective :

- . the ground simulator permitted very high angle of attack manoeuvres to be made at very low speeds near to the ground but did not permit exact reproduction of the flight environment (outside display limited, different piloting sensations). Also, it is impossible to exactly reproduce the flight from the DFDR information as the recording rates are too low for this.
- . the real aircraft is of course highly representative, but for flight safety reasons, we could not go too close to the actual conditions of the accident.

In neither case, was it possible to represent exactly the atmospheric conditions present during the flight which led to the accident but, à priori, this aspect had only a very marginal influence in the case considered (the atmosphere was calm at Habsheim on June 26th).

The tests carried out were as follows :

- on ground-based simulator :

The simulator having been placed in initial conditions from which it was possible to reach a point in the flight envelope (altitude - speed) measured on the recording of the approach of June 26th, the pilot at the controls of the simulator attempted to reach this point then to pass through the same flight envelope point values (altitude - speed) in a certain number of cases measured on the DFDR. During this test, in which several attempts were required to obtain correct simulations, the aircraft configuration was fixed (aircraft weight and CG position in compliance with those of the flight, landing gear extended, slats 22°, flaps 20°). During the major part of the approach, engines were at idle and the pilot used only the pitch control to perform the test.

(1) the accuracy of the simulator in representing the aircraft was checked by specialists from the Flight Test Center who had participated in the A 320 type certification tests.

- in flight :

- . study of the behaviour of the aircraft at very low speeds,
- . assessment of the influence of the modifications of the flight control laws at very low height during flights over the runway at Toulouse in the approach configuration of the F-GFKC on June 26th 1988.

1.16.1.4 - Results

1.16.1.4.1 - Reconstruction of performance
(variation of altitude and speed)

The two tests on the simulator considered as the most representative were retained for the analysis which mainly concerned the final phase of the flight (from 50 feet).

In both cases, the altitude and speed parameters were very well reproduced and the agreement with the flight in which the accident occurred can be considered as excellent from this point of view.

In the first case ("nominal" case), the differences of the speed in relation to time are in general less than 1kt (compared with the accuracy of this parameter during the DFDR recording : - 0.5 kt), the differences in altitude are small (+ 10 feet maximum 13 to 14 seconds before the time of impact, - 5 feet on average during the last seconds) (1). It must be underlined that the pilot at the controls tried to pass via given altitude-speed pairs identical to those recorded in flight but that the moment when he reached them results only from the simulation calculations. The fact that the altitude and speed curves are practically in compliance with the data obtained from the recorder with respect to time shows that the real aircraft behaved in this respect in the same way as the certificated aircraft (the characteristics of which are integrated into the simulator).

However, a slight difference must be noted in this case : at t-12s and t-13s, the speed reproduced on the simulator was slightly higher than that of the flight of the accident (+ 2 to 3 kt).

In the second case, when the President of the Investigation Commission piloted the simulator, the agreement of the variation of speed with respect to time is also excellent, the flight altitude simulated was very slightly higher than that of the actual flight (+ 8 to 10 feet). The same difference also exists with the real flight on the radio altimeter altitude between t-21s and t-20s.

(1) We can however note between t-21s and t-20 seconds a significant difference between the altitude measured by the radio altimeter and the altitude of the simulated flight : this is, in fact, a short phase during which the radio altimeter information was wrong (see paragraph 1.16.3) ; the comparison with the barometric altitude shows excellent agreement between the flight made on June 26th and the simulated flight.

We also have the same discrepancy as in the previous case : at t-12s and t-13s, the speed reproduced in the simulator is slightly higher than that of the flight in which the accident occurred (+ 1 to 2kt).

This discrepancy can be explained by a low amplitude atmospheric disturbance during the flight, not reproduced by the simulator. The behaviour of the aircraft after t-10s is however in compliance with the model, which indicates that this disturbance only had a very minor effect on the aircraft flight path.

In flight tests, the performance comparison between flight No. 260 and the flight of the accident is good (see sheet given in appendix).

This fact enables us to conclude that the aircraft configuration was indeed the same and correctly reproduced.

1.16.1.4.2 - Response of the aircraft to a pitch actuation at very low speed :

The difficulty of reproducing a manoeuvre arises from the fact that we must place ourselves in identical or nearly identical flight control law conditions implying the observance of all relevant parameters (load factor or attitude, angle of attack, speed gradient, positions of sidestick in pitch) but these parameters are recorded only at a low rate on the DFDR (in general, one point per second) whereas an exact reconstruction would require around 40 points per second. In the majority of the tests conducted on the simulator and in flight to assess the behaviour of the aircraft at very high angle of attack, the pitch control was brought to the rear stop more rapidly than during the flight on June 26th in the phase immediately preceding impact with the trees.

However, specific tests relevant to this last flight phase permitted us to check that the response of the aircraft to the pitch command given by the Captain was also in compliance with the certification data :

- on the simulator, the sheet given in the appendix shows that, for the test performed with a stick deflection rate identical to that of the flight on June 26th, the attitude response is perfectly in compliance on the simulator and during flight, after resynchronising from the time when the Alpha Prot law was activated,
- it was also possible to make a reconstruction in flight during flight No. 355 on A 320 No. 3 :

The parameters recorded during this test are compared on the sheet with those of the flight of June 26th. The differences between the two cases are as follows :

- . flight test No. 355 was made at a speed lower than that of the flight on June 26th, the weight of the aircraft was lower, the angles of attack were more or less the same,
- . the variation of attitude and altitude was different (aircraft descending during flight No. 355, in level flight for the flight on June 26th),

- . the pitch control was brought to the rear stop more slowly than on the flight of June 26th, but from a balance position nearer to neutral,
- . lastly, during flight No. 355, made at altitude, control was by the C* law (load factor) before changing to the angle-of-attack protection law whereas for the flight on June 26th, control was by the pitch attitude control law before changing to the angle-of-attack protection law.

As the objective is to compare the response of the aircraft when it was under the angle-of-attack protection law (in the last seconds of the flight), the effect of these differences can be considered to be marginal, especially as the average deceleration of the aircraft is very close in both cases.

We can see that the variations in the angle of attack were also very similar : the increase in the measured angle of attack is almost identical during the last two seconds (1°).

The other calculations made also show that if the pitch control had been moved back more rapidly or earlier during the flight in which the accident occurred, an angle of attack greater than 15° could have been obtained before impact with the trees. They also show that, without earlier initiation of go-around, such a manoeuvre would have led to an increase in the instantaneous drag of the aircraft and would not have prevented impact with the trees.

1.16.1.4.3 - Analysis of the aircraft response for the different flight control laws active during the approach

Certain members of the Investigation Commission, themselves pilots, wished to assess personally the behaviour of the aircraft during manoeuvres made near to the ground to check if the switchover of the flight control laws could lead to handling difficulties. To this end, tests were carried out above the Toulouse runway in level flight between 100 and 50 feet (C* law), between 50 and 30 feet (pitch attitude law) and below 30 feet (attitude and derotation law). These flight cases, which did not correspond to normal approaches, revealed no handling problems : the switchover from C* law to pitch attitude law had no noticeable effect on the behaviour of the aircraft observed by the pilot, the effect of the derotation term was perceptible (increasing pressure must be applied rearward to keep level flight) without this being tricky and it must be remembered that this mode was not activated during the flight on June 26th.

Switchover to the angle-of-attack protection law also had no effects on the behaviour of the aircraft as felt by the pilot.

These tests also enabled us to establish that the very momentary switchovers of the flight control laws which occurred between t-21s and t-20s due to the erratic indications given by the radio altimeter during the flight over a clump of trees were not of a nature to affect the behaviour of the aircraft.

To sum up, the Investigation Commission established that the performance of the flight controls was in compliance with the certification data during the flight made on June 26th 1988 and they consider that the flight control laws of the aircraft show no characteristics liable to create any specific handling difficulties even under the conditions of this flight which differed noticeably from those of a normal approach.

1.16.2 - Engine operation

Unlike the flight controls, the behaviour of the engines was questioned by the crew immediately after the accident : they declared that, after initiating go-around, engine thrust was not achieved.

From the very first investigations made on the recorders (CVR and DFDR), it was however established that the engines had responded to the go-around initiation made between 5 and 5.5 seconds before the impact with the trees (variation of engine speeds, temperatures and fuel flow rates on the two engines recorded on the DFDR ; noises characteristic of changes in engine speeds recorded on the CVR).

The Commission therefore concentrated their work on checking the circumstances of the go-around by :

- reproducing as accurately as possible the engine parameters,
- comparing the observed behaviour with the normal certification characteristics.

The Commission also participated in the engine examination made by the manufacturer CFMI (in the SNECMA premises at Melun-Villaroche).

1.16.2.1 - Reproduction of the engine parameters during go-around

The characteristic engine acceleration parameters after go-around initiation were reproduced from three independent sources :

- the engine parameters recorded on the DFDR,
- the spectral analysis of the last seconds of the CVR recording, the characteristic frequencies of the engine speeds having been recorded by the cockpit area microphone,

- the spectral analysis of the sound track of a video film shot by a spectator on the ground.

The results of these analyses are perfectly in agreement and show that the engines increased in power as soon as go-around was initiated.

The last engine speeds recorded by the CVR and the DFDR were 84.4 % N1 on the CVR, 83 and 84 % N1 on the DFDR. The sound track of the video film permitted reproduction of several additional seconds after the impact with the trees (when the flight recorders were no longer operating) : the last maximum speed value, clearly identified from this source, was 91 % N1.

1.16.2.2 - Comparison with basic certification data

As the engine responses had been reproduced without ambiguity, the Commission checked their conformity with the basic certification data.

The certification regulations in particular require that the climb gradient of the aircraft in landing configuration, all engines operating, must be at least equal to 3.2 % with thrust available 8 seconds after initiating go-around. This statutory requirement is reflected by a minimum thrust value and, therefore a minimum N1 speed, taking into account the aircraft drag characteristics. In the flight conditions of June 26th, this minimum N1 speed value was 94 % (value which must be obtained 8 seconds after initiating go-around).

In the case of this flight, the impact with the trees occurred before 8 seconds had elapsed after initiation of go-around (see below). The Commission therefore sought the minimum N1 engine speed values for the period between 5 and 8 seconds after initiation of go-around in the conditions of the flight and corresponding to go-arounds which would satisfy the regulations. These values are given on the curve at the end of the paragraph.

The exact moment when go-around was initiated by the pilot during the Habsheim overflight was determined as follows :

- The position of the throttles recorded by the DFDR, every two seconds, indicated : flight idle position at 12h 45mn 33s, TOGA position at 12h 45mn 35s. Between 12h 45mn 34s and 12h 45mn 35s, engine 1 N2 speed and flow started to increase (this information is taken in the middle of the cycle).
- The recording made in the cockpit by the CVR shows that the throttles were placed in TOGA position at 12h 45mn 34s 5/10.

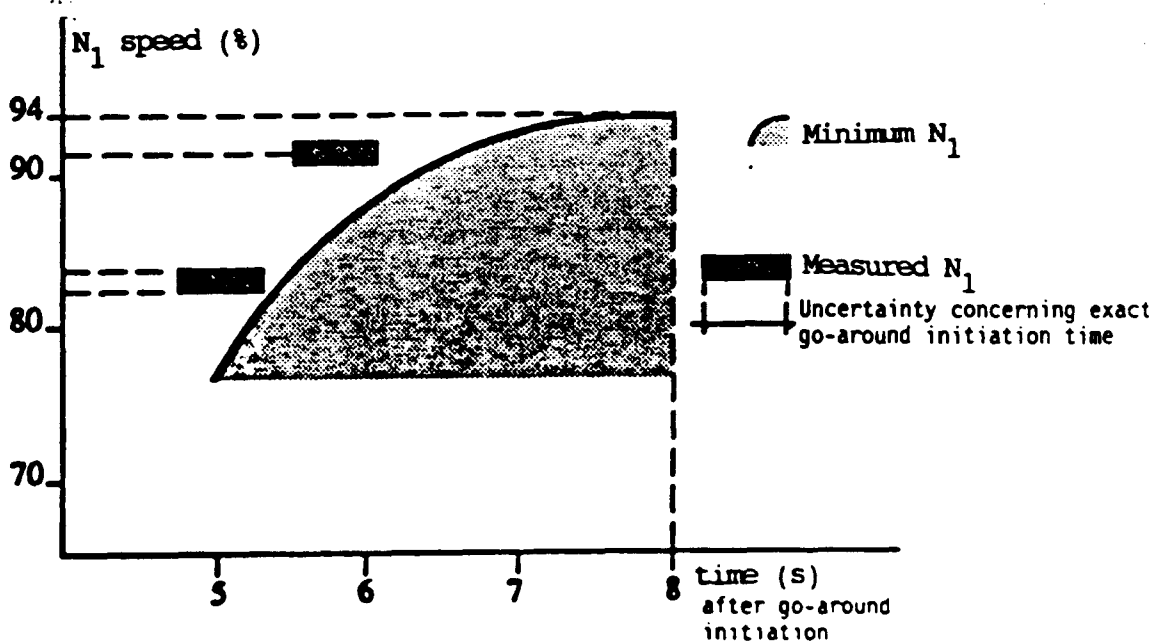
- The eye-witness reports refer to a definitive and rapid application of go-around power.

From these considerations, it can be estimated that go-around was initiated between 12h 45mn 34s and 12h 45mn 34s 4/10.

The N_1 speeds recorded on the DFDR at 12h 45mn 39s are respectively 83 and 84 % for engines 1 and 2 (i.e. 5 to 5.4s after initiation of go-around).

The speeds measured by external means are 91 % 0.6s after having reached 83 %.

Under these conditions, the curve below compares these recorded speeds to the minimum speeds required to meet the certification requirements. We can conclude that the engine acceleration was in compliance with these requirements.



It was thus verified that the engine acceleration defect sometimes reported in certain low altitude flight cases on the A 320 did not occur during the flight on June 26th. Also, the conditions required for this to occur were not present (speed much lower than 250kt).

1.16.2.3 - Detailed engine investigation

The engine investigation showed that the engines were practically stopped during final impact on the basis of the following :

- no signs of fan rotation were found even though, after the impact, moving blades were in contact with fixed parts,
- signs of low speed rotation of HP system are visible at time of impact with the ground,
- all the undamaged variable bleed valves (VBV) of the low pressure compressors were in the open position, i.e. corresponding to idle speed or shut-down.

It was also found that the combustion chambers were almost completely blocked by a compact mixture of partially burnt wood and leaf debris.

With these elements established, it must be underlined that the fact that the motors were practically stopped during final impact does not contradict the fact that they were operating normally before impact with the trees : the falling of the aircraft into the forest led to massive ingestion of branches and leaves via the air intakes and this caused the engines to stop by obstructing the combustion chambers. The engine speed fell rapidly and the regulation system, mainly controlled by N2 speed, brought the VSV and the VBV into a position compatible with a low N2 speed, and this explains why the VSV and VBV were found in a position corresponding to idle speed.

1.16.2.4 - Conclusions concerning engine operation

To sum up, the Investigation Commission established that the engine acceleration during the flight in which the accident occurred was perfectly in compliance with the basic certification data and that their operation was normal up to the moment when, after impact with the trees, they started to absorb the vegetation debris during the final falling of the aircraft into the forest.

1.16.3 - Additional investigations

In their investigations to check if the operation of the aircraft had been correct on June 26th, the Commission was also led to study the reasons which could explain the apparently irregular radio altimeter announcement sequence : 200 feet, 100 feet followed by 40 feet then 50 feet...(whereas 50 feet should have been broadcast before 40 feet).

On the aircraft intended for AIR FRANCE, the aural announcements provided for in the program are (height in feet) :

- 200, 100, 50, 40, 30, 20, 10, 5,

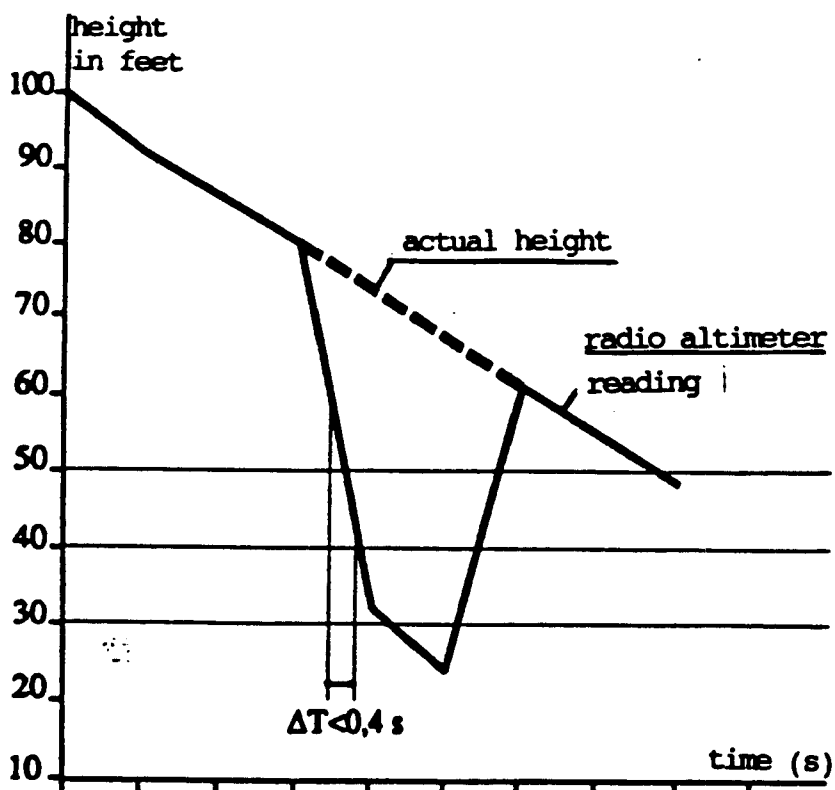
- and for approaches for which the crew has selected a decision height DH (approach in low visibility conditions) : HUNDRED ABOVE when passing through DH + 100 feet and MINIMUM on passage through DH.

The predetermined announcements are triggered 10 feet above the altitudes to be announced for those greater than or equal to 100 feet and 2 feet above for those less than 100 feet.

The time required to generate an announcement from the trigger threshold is on average 0.4 seconds. If an announcement is started (synthetic voice starts to speak), it is pronounced entirely. If, another height, associated with another announcement, is detected before the first announcement begins, the first announcement is not broadcast, as priority is given to the second value to be announced. The aural announcement is also inhibited if the two radio altimeters are inoperative, if radio altimeter altitude is lower than 3 feet or if radio altimeter altitude increases.

Above 50 feet, intermediate announcements (repetition of same announcement when the following threshold is not crossed) are generated every 11 seconds. Below 50 feet, this time is reduced to 4 seconds.

In case of the flight made on June 26th, when the actual height of the aircraft was decreasing continuously from 100 to 50 feet between 12h 45mn 15s and 12h 45mn 23s, there was a discontinuity in the radio altimeter information between 12h 45mn 18s and 12h 45mn 19s. The evolution of these readings was in compliance with the curve below :



This discontinuity comes from flight over a clump of trees located shortly before the runway. The 50 feet announcement, triggered by passing through a height of 52 feet, was inhibited as the 40 feet announcement was triggered, by passing through a height of 42 feet, less than 0.4 sec. after the 50 feet announcement had been triggered.

The 40 feet announcement was therefore made without the 50 feet announcement having been made and before the 30 feet announcement was triggered. This 30 feet announcement was inhibited as at the time when it should have been announced, the radio altimeter altitude was increasing.

After time 12h 45mn 20s, the announcement sequence presented no irregularities. Note, however, the repetition of the 30 feet announcements at very short intervals during the last flight phase. These repetitions can be explained only by very low oscillations of the radio altimeter height around the 30 feet value, the announcement being triggered each time that the 32 feet height was passed after an increase in altitude even very brief, had been recorded (these very low altitude oscillations may have been flying oscillations or the result of a very low altitude variations in the terrain flown over : an 8 cm height variation 3.5m wide is sufficient to rearm the announcement).

2 - ANALYSIS

2.1 - GENERAL CONSIDERATIONS

The Commission found that the aircraft was airworthy, that the weight and CG were within the authorized limits and, more generally, that there was no evidence of any mechanical or instrumental failure (before the first impacts with the trees), liable to reduce safety. On the contrary the Commission became convinced that the behaviour of the aircraft had been, from all points of view, in compliance with the certification data and that the flight path followed was in accordance with the flight control commands given by the crew via the flight controls.

They also determined that the weather conditions and lighting conditions and also the aerodrome infrastructure, navigation aids and telecommunications played no part in the accident. The crew, normally qualified to fly Airbus A 320s, showed no medical or pathological evidence which may have been liable to influence the flight.

The Commission were thus led to concentrate their study on the circumstances of the preparation for the flight and on the elements liable to have influenced the behaviour of the crew during the flight as they flew the aircraft on a flight path appreciably different from the one that they had explicitly planned before the flight.

2.2 - FLIGHT PREPARATION

2.2.1 - Study of the feasibility of the flight over Habsheim aerodrome

According to the departments of AIR FRANCE responsible for the flight preparation, the low altitude overflights had been studied as provided for in AIR FRANCE's internal note DO ND 50420. This study would mainly have consisted in checking obstacle clearance in case of engine failure.

According to the airline, these flybys were studied for flight over runway 02.

This declaration led the Commission to make the following remarks :

1) The hard runway 02 at Mulhouse-Habsheim cannot be used by the A 320, due mainly to the fact that its strength is too low,

2) The runway to be used could not have been foreseen at the time when the flight was prepared by the department concerned (weather conditions unknown and AIR FRANCE not notified of the runway selected by the organizers).

Note DO ND 50420 was drawn up by AIR FRANCE to prevent demonstration flights from being made at heights which are too low. This note specifies, inter alia, that all or part of a tourist or demonstration flight must be subject to : "accurate definition of the way in which the flight will be carried out (distance, altitude, configuration, etc.) and the corresponding task sharing".

These directives should have been drawn up by the flight division but :

- . It was only on the Friday afternoon that the flight file was handed over, by the employee responsible for its preparation, to the technical assistant of the division at the moment when he was leaving. Reception of this document therefore seems to have been fortuitous.
- . Also, the persons responsible within the flight division did not deal with this earlier probably due to their workload related to the entry into service of the aircraft.
- . From the file (which did not indicate any particular difficulties), they estimated that Michel ASSELINE was perfectly capable of planning this flight himself given his position in the company and his strong personality, which resulted in him having a field of action much greater than appears in the airline's organization chart.

Consequently, the file was handed over as it stood to the crew. It included none of the items required by note DO ND 50420 nor any indication of height or overflight axis to be observed or any direct means of contact with the air show organizers.

The Commission considered that, as no such indications were given, the crew should have referred to DO ND 50420.

This note specifies that "a minimum runway overflight height of 100 feet in landing configuration" must be observed.

The Commission remarked that :

- 1) The note was not appended to the file handed over to the crew even if its existence is recalled in a message.
- 2) The 100 feet height was not applicable to the Mulhouse-Habsheim overflight as none of the runways was usable by the A 320.

3) Also, the choice of a height of 100 feet is in contradiction with the French air safety regulations which impose a minimum overflight height of 170 feet using VFR (this flight phase was carried out under VFR even though under an IFR flight plan).

The Commission also observed that within the scope of touristic or demonstration flights, the 100 feet agl height had already been used by AIR FRANCE to perform many overflights, including over grass runways, (more than twenty since 1987), during air shows in France and abroad.

The Investigation Commission noted that the overflight height above the aerodromes where the air shows were held, even though not in compliance with the regulations, had not led to reactions from the Administration, or from the air show organizers (except on one occasion where the flyover conditions and height, lower than the fixed minimum, had given rise to actions from the competent interministerial (Home, Defence, Civil Aviation) control commission).

2.2.2 - Distribution of the results of the study and provision of information to the crew

The Department who made the study informed the Air Operations Directorate and the Flight Safety Department of AIR FRANCE, as well as the Regional Air Traffic Control (East) and the Basle-Mulhouse tower by Telex. Then they handed over the file to the A 320 flight division.

Due to the short period of time available, the technical assistant did not have time to make verbal comments on the file to the Captain who was on flying duty on June 25th. The First Officer, who that day was resting, was not contacted.

The pilots were chosen for this flight as they had managerial responsibilities. Reconnaissance of the Habsheim aerodrome by the crew was at no time considered.

The meeting provided for in the regulations, on its initiative, between the air show flight manager and the crew did not take place thus depriving them of information which could have been useful (special features of the terrain, axis used, location of public, etc.).

The organizer had held that same morning a preparation meeting with all the other pilots concerned but was not worried by the absence of the A 320 crew due to the correct performance of flights made during AIR FRANCE participation in previous air shows at Habsheim and the freeing of the airspace planned from the moment when the aircraft was to take off from Basle-Mulhouse.

The crew, therefore, had received no information or verbal comments on the file drawn up for them.

2.2.3 - Flight preparation by the crew

2.2.3.1 - The study of the file (including the prefectural authorization number, photocopies of the 1/500,000 scale VFR flight chart, IGN 1/100,000 scale map, VAL chart of the Mulhouse-Habsheim terrain) was only made by the two pilots on Sunday morning June 26th. They therefore made the flight preparation only from items differing from their normal working documentation and describing an aerodrome and its surroundings which they did not know and on which, due to lack of directives, they had free manoeuvre choice.

Neither of the two pilots had previously performed a demonstration flight.

The Commission noted that they seemed not to have tried to obtain additional information concerning these overflights.

It is probable that the Captain, on seeing the file, judged that the flyovers presented no difficulties and that he had no need for additional information. Also, the AIR FRANCE personnel directly concerned would no doubt not have been easy to contact on a Sunday.

2.2.3.2 - At BASLE-MULHOUSE, during taxiing, the Captain made a briefing on the two low altitude flyovers at the Habsheim airfield. The axis of the runway which was finally chosen because of the terrain and the public was not mentioned. The two flyovers were planned without a previous flight over the aerodrome, one at low speed, the other at high speed.

The flyover conditions were also explained as follows :

First flyover to be performed :

- 1) at 100 feet,
- 2) with flaps in position 3 and landing gear extended,
- 3) in level flight decelerating to maximum angle of attack permitted by the A 320 flight control system,
- 4) after disengagement of automatic go-around protection at high angle of attack (alpha-floor),
- 5) with assistance to control the aircraft required of the First Officer if holding the load on the stick became uncomfortable ("...If I tell you it is hard..."),
- 6) maintaining level flight with the aid of the engines by the First Officer,
- 7) with go-around initiated by the First Officer on order from the Captain.

The second flyover was to be performed :

8) by the First Officer, also at 100 feet, at high speed and in clean configuration.

These 8 points lead to the following comments :

1) As we have seen in paragraph 2.2.1, the 100 feet flyover height, also not in compliance with regulations, does comply with internal note DO ND 50420. For the crew, flying at this height could therefore be considered as authorized and therefore as normal.

Note that no mention is made of the reference selected for the 100 feet : barometric height (QFE) or radio altimeter height.

2) This flap and landing gear configuration is one of the normal landing configurations.

3) The deceleration in level flight was planned down to minimum flight speed corresponding to the maximum angle of attack permitted by the aircraft fly-by-wire systems. This shows, on the part of the Captain, his desire to highlight the value of the A 320 by demonstrating its specific possibilities.

The training given to the pilots emphasized all the protections from which the A 320 benefits with respect to its lift which could have given them the feeling, which indeed is justified, of increased safety. In particular, the demonstration of the activation of the safety features and protection of this aircraft may lead one to consider flight approaching one of the limitations (especially the one related to angle of attack) as a foreseeable flight condition since lift is guaranteed.

However, emphasis was perhaps not sufficiently placed on the fact that, if the limit cannot be exceeded, it nevertheless exists and still affects the performance, i.e. the ability to change the aircraft flight path. As on conventional aircraft, the load factor available at minimum speed in level flight is only one (zero manoeuvrability in recovery and turn) and the drag at this speed is very high (back side of the drag curve) which greatly limits the climb gradients as the available excess thrust is naturally low.

During training on previous generation aircraft, pilots are made aware of the dangers of flight at low speed, and the basic rule which consists in observing a margin with respect to a minimum speed is driven home. The pilots would therefore probably not have considered such a manoeuvre at a speed so close to stall on these types of aircraft. However, for the flight of the accident, the crew did not hesitate to plan a low height flyover at a speed lower than approach speed (normal minimum operating speed) without realizing that, because of the protection, the aircraft limits were reached without risk of exceeding them, but that performance was reduced in the same way as on conventional aircraft.

4) The choice to inhibit the automatic go-around protection (Alpha Floor) resulted from the need to eliminate this protection if flight at 100 feet or above is planned at an angle of attack higher than the one activating this protection. The inhibition in this case can only be achieved in practice by pressing and holding the two switches placed on the throttles. After 30 seconds, inhibition becomes permanent for the rest of the flight.

This decision is compatible with the objective expressed by the Captain to maintain a height of 100 feet and seems to confirm that the incursion below 100 feet was not considered by him at this stage. In effect, below 100 feet, this protection is not active.

5) The request for help to control the aircraft made to the First Officer can only be explained by concern about the discomfort caused by a sustained nose-up action, which seems to indicate that the Captain thought that he had time to make a prolonged level flight above the runway at maximum stabilized angle of attack.

6) The request made to the First Officer to maintain level flight by adjusting the engine speed confirms the previous remark.

7) The application of power was planned to be made by the First Officer on the order ("au TOP") of the Captain. The latter was therefore envisaging a go-around starting from the power setting necessary to maintain level-flight, in other words from a high power-setting.

On the A 320, the training demonstrations of the behaviour of the aircraft at low speed are only made from stabilized level flight at a speed near to minimum speed and therefore with a thrust near to the equilibrium thrust at maximum angle of attack. In this case, go-around is made from a high engine speed and gain in altitude appears immediate and the aircraft remains in maximum angle of attack. Note that this type of demonstration is highly impressive : climb with pitch control set to full nose-up while making roll manoeuvres gives the feeling of great safety.

8) The height of 100 feet planned for the second high speed flyover is not in compliance with note DO ND 50420 which specifies a minimum height of 300 feet for this type of overflight. The choice of the height of 100 feet was perhaps made due to only partial knowledge of this note.

The Commission observes that :

- the prolonged level flight mentioned in 5 could not be achieved (length of runway). There is also a lack of precision concerning the go-around initiation point.

These two points show the incomplete character of the flight preparation.

- the task sharing concerning look out and monitoring of the instruments is not mentioned ; even if this task sharing could seem obvious for each of the pilots, this aspect should have been dealt with due to the character of the flight (demonstration flight and, moreover, crew made up of two instructor Captains).
- the comment made by the Captain indicating that he had already made this manoeuvre 20 times is probably pertinent as concerns the number, but not as concerns the height at which the Alpha protection was activated during his training flights as instructor or trainee.

2.3 - SEQUENCE OF EVENTS

After a 6-minute wait due to the traffic, the aircraft lined up on the runway and took off at 12h 41. It turned right immediately to head towards the Habsheim aerodrome. The take off and climb to 2000 feet QNH lasted 2 minutes during which the pilots were occupied by the management of the flight and by unwanted warnings leading, on the part of the Captain, to remarks confirming his profound knowledge of the aircraft.

Then the crew tried to identify the Habsheim aerodrome which they did not know ; the descent was only started (with an initial speed of 190kt) at 5.5 Nm from the aerodrome, a distance which turned out to be too short to achieve the desired loss of height and deceleration sufficiently quickly to permit stabilized level flight.

During the descent, the First Officer made contact with the Habsheim tower and specified : "we're going in for the low altitude low speed flyover" which corresponded to the briefing and did not incite a remark from the Captain ; the controller gave the QFE altimeter setting ; the two pilots repeated this and indicated that they had selected and checked it.

The Captain asked the First Officer to confirm if that was indeed the airfield when they passed 450 feet measured on the radio altimeter.

This request can be explained by the habit of making checks for all flight phases, especially during approach.

Also, at this time, the Captain is, without doubt, trying to find the runway above which the manoeuvre is to be made. It is only when he sees the crowd of spectators that he decides, in accordance with his declarations, to overfly 34R without however telling the First Officer.

The GPWS announcement at 300 feet radio altimeter comes from the fact that it was not in "flaps 3" mode. The chime which follows corresponds, according to the crew, to the switching off of the GPWS. This was done, instead of selecting "flaps 3" mode, probably to prevent further warnings during the demonstration.

At 12h 45mn 11s, the First Officer made a comment concerning the AIR FRANCE flight safety officer whose function consists, among other things, of studying the flights for which the safety margins have not been observed. This comment can be interpreted in different ways : either anticipated self satisfaction before the planned demonstration or, more likely, according to the Commission, a warning for the Captain.

It can be seen that the First Officer stops in the middle of his remark when the "200 feet" aural announcement of the radio altimeter is made. The pilots therefore heard this announcement (maybe without identifying it) the volume of which is sufficient to justify interruption of the phrase being spoken even though both of them are using headsets (the radio altimeter announcement is only broadcast by the cockpit loudspeaker and not in the headsets but these, being lightweight, enable the noises in the cockpit to be heard).

At 12h 45mn 14s, the First Officer notifies the Captain that they are reaching the height planned for level flight : "OK, you're at 100 feet there, watch, watch ...".

Here again, the First Officer interrupted his sentence at the 100 feet radio altimeter announcement which shows that he heard this sound. Also, this coincidence indicates that, either he was using the radio altimeter as the height reference or that the altimeter indications were consistent with those of the radio altimeter.

Due to the remark made at 12h 45mn 32s ("watch out for the pylons ahead ...") we can consider that the "watch, watch ..." corresponded to the start of a new warning, as the aircraft was arriving at the selected height with a still significant descent rate (600 feet/mn approx.).

The Captain at the controls did not react either to the radio altimeter announcements of fifty and forty feet or to a possible reading of the instruments and as concerns the warning about the pylons, he dismisses it with a short phrase ("Yeah, Yeah, don't worry").

Since, for the remainder of the flight, the radio altimeter was registering less than 100 feet, Alpha Floor protection was automatically deactivated.

A problem of reference is raised for the 100 feet flyover margin : the radio altimeter readings are only valid for flat terrain or over a topographically known contour with electrically well flagged points (ILS approaches). On the other hand, the barometric altimeter is an instrument whose intrinsic accuracy at low altitude is around 30 feet. The altimeter reference pressure is supplied to within 0.5 hPa which corresponds to 15 feet. A low flyover based on the barometric altimeter cannot then, a priori, be accurately achieved.

These considerations may have led the crew to have only limited confidence in the readings of these two instruments.

If the descent observed below the planned height was not made voluntarily, this supposes that the Captain was flying by sight and that he had not registered the aural announcements made by the radio altimeter as he was occupied with other tasks. It is interesting to specify the various factors which could have led to error :

- he was flying over a terrain that he did not know and had not had the possibility of studying as he had not made prior reconnaissance (either from the ground or in flight). Also, he had only had a short time to consult his file which, moreover, was very brief. He therefore had no accurate geographical landmarks.
- whereas he was accustomed to use 2 to 3000 m long runways with approx. 100-foot high control towers, he found himself on an 800 m long grass strip with a 40-foot high tower ; the scale effect may have created a false impression making him think that he was at the planned height.
- due to the high nose-up attitude of the aircraft, the pilot's eye level was much higher than the rear section of the fuselage and this gave him a false impression of the height margin of the aircraft with respect to the obstacles.
- also, at the start of the overflight the trees were perceived only as a change in colour with respect to the grass of the runway and not as a change in contour ; the crew no doubt only identified them as an obstacle at a very late stage as indicated by the remark made by the First Officer who was concerned about the pylons which were approximately 1.5km distant but not about the nearby trees.

Also, by the reply made to the previous warning : "Yeah, yeah, don't worry", and his remark during the briefing : "I've done it 20 times", the pilot appeared very confident. We can try to explain this frame of mind by the following considerations :

- Because of his work on the A 320 simulators and his participation in the development of the aircraft, he knew the A 320 better than most of his colleagues.
- He had often performed similar manoeuvres at high altitude and on the simulator ; he knew all the special protections introduced into the A 320 flight control laws especially the stall protection and he could, therefore, have thought himself fully protected for his high angle of attack flyover, even at a very low altitude.
- As these same manoeuvres were generally made with a stabilized engine speed well above idle, the thrust was established very quickly permitting immediate increase in height.

Also, an air show is the ideal occasion to demonstrate the possibilities of the A 320 of which he was an ardent advocate. The choice of a flyover at maximum angle of attack may also have been the result of the atmosphere created by the "air show festivities" on the ground and on-board and the presence of female passengers in the cockpit.

At 12h 45mn 26s, when he placed the aircraft in level flight, the Captain indicated that he was disconnecting the autothrottle ; this operation had already been performed at 12h 41mn 58s. The Captain later stated that, in this case, it was "a safety measure" intended to guarantee full application of thrust when required by him.

We can remark that this action was of no use for the intended objective : irrespective of the autothrottle situation, engine power increase is identical when the throttles are brought to TOGA position.

At 12h 45mn 34s 5/10, when the aircraft passed in front of the control tower, the Captain rapidly placed the throttles in the position corresponding to max. thrust (TOGA). This was not in compliance with the program which specified gradual and partial application of power made by the First Officer to keep level flight at maximum angle of attack then throttle up to TOGA also by the First Officer.

Three seconds after having applied go-around thrust, the pilot gradually brought the pitch control to full nose-up position.

It is probable that these actions of the Captain (application of go-around thrust and nose-up command) were motivated by a sudden awareness of danger.

At this moment in time, the aircraft was at low speed and at very low height ; it had no energy reserves, neither kinetic nor potential.

Also, the engines, at flight idle when go-around was initiated, could not instantly supply high thrust due to their inertia. One can very easily explain the pilots' impression of a lack of response of the engines (this impression was also felt by the members of the Commission during the reproduction flights carried out in the course of the investigation). Engine acceleration is slower at low speeds : 4 seconds are required to go from 29 % N1 to 67 % N1 and only 1 second to go from 67 % N1 to 83 % N1, the engine speed which had been reached when first contact with the trees was made 5 seconds after initiating go-around.

The engine speeds increased at least up to 91 % (last value obtained by spectral analysis of the sound track of the video recording of the accident) but, at that time, the rear section of the fuselage had already hit the trees, creating additional drag which prevented the aircraft from gaining height. Following this, the engines ingested a high quantity of leaves and branches which were mashed up in the compressor and clogged the entry to the combustion chambers causing shutdown of the two engines. The aircraft sank into the trees and was rapidly slowed down.

3 - CONCLUSIONS

3.1 - FACTS ESTABLISHED BY THE INVESTIGATION

- The aircraft was in a flightworthy condition
- The weight and balance were within authorized limits ; the errors in their calculation did not in any way influence the flight.
- The Commission found no malfunction of the aircraft or its equipment which could have contributed towards a reduction in safety or an increase in the crew's workload during the final flight phase.
- The crew held the valid certificates and licences and had the qualifications required to operate the aircraft.
- The two pilots held management positions in their airline and participated, at various stages, in the development and the entry into service of the A320.
- Neither of the two pilots had previously made a demonstration flight.
- As concerns the crew, no physiological factor or medical history was found that could have played a role in the accident.
- The planned flight programme included flybys over the Mulhouse-Habsheim aerodrome as part of an airshow.
- To prepare for this flight, the crew were in possession of a short brief for the part concerning the overflights.
- The crew had only partial information on the organization of the airshow, particularly because of the absence of prior contact between the organizers and the crew.
- During taxiing at Basle-Mulhouse, before take-off, the Captain specified his intentions for the overflights at Habsheim : overflight at 100 feet with flaps in position 3 and landing gear extended, deceleration in level flight down to minimum airspeed corresponding to maximum angle of attack, stabilization at this minimum speed, then application of full power on the Captain's order. Then a second flyover at high speed also at 100 feet.
- Locating of the aerodrome was late.

- Descent was started at 12h 43mn 44s at 5.5 nautical miles from the aerodrome, the engines were throttled back to flight idle throughout the descent, with the speed reducing.
- When 100 feet agl was reached, the descent rate was still about 600 feet/min.
- The pilot levelled off at a height of about 30 feet, engines at flight idle, attitude increasing. He did not have the time to stabilize the angle of attack at the maximum value that he had selected.
- Rapid application of full power occurred between 12h 45mn 34s and 12h 45mn 35s ; the angle of attack was at this time 15° and the speed 122 knots.
- The response of the engines was normal and in compliance with certification requirements.
- The aircraft touched the trees between 12h 45mn 39s and 12h 45mn 40s with the rear section of the fuselage and then slowly sank into the forest as a result of the induced drag and the loss of engine power caused by ingestion of leaves and branches.
- A very violent fire broke out immediately, mainly at the right of the aircraft, and flames penetrated the cabin as soon as the aircraft came to rest.
- Evacuation was begun immediately by the cabin attendants via the forward and rear left-side doors.
- Three passengers were unable to leave the cabin and died in the fire.

3.2 - PROBABLE CAUSES

3.2.1 - Cause

The Commission believes that the accident resulted from the combination of the following conditions :

- very low flyover height, lower than surrounding obstacles.
- speed very slow and reducing to reach maximum possible angle of attack.
- engine speed at flight idle.
- late application of go-around power.

This combination of conditions led to impact of the aircraft with the trees.

The Commission also believes that if the descent below 100 feet was not deliberate, it may have resulted from failure to take proper account of the visual and aural information intended to give the height of the aircraft.

3.2.2 - Other factors

The Commission also remarked that the following factors contributed towards placing the crew in a situation that they were not able to fully control :

- The flight preparation was insufficient, especially due to the brevity and late provision of the brief and of the information about the airshow.
- The task sharing planned for the flyover by the crew was incomplete and was not followed.
- The holiday atmosphere for the passengers and the spectators could have been transmitted to the Captain.
- The A 320 has new features which may have inspired some overconfidence in the mind of the Captain.
- These new features of the aircraft had sometimes been criticized and the Captain wanted to defend the aircraft.
- Neither of the two pilots had previous experience of demonstration flights.
- The late identification of the aerodrome led to a rush of events, and the making of the descent and then the complete flyover above the runway with the engines at flight idle, and without stabilizing the flight parameters.
- Neither of the two pilots had previous experience of applying go-around power from flight idle in similar conditions.

4 - RECOMMENDATIONS

4.1 - ADMINISTRATIVE AND TECHNICAL PREPARATION FOR FLIGHT

4.1.1 - The Investigation Commission remarked that the flight which led to the accident had only been briefly prepared without real consultation either between the departments concerned, or with the crew.

The Commission recommends that :

- the preparation of such flights (participation in air shows) includes as a minimum and in addition to the actions already explicitly provided for in the regulations :
- the drawing-up of a comprehensive flight safety brief specifying the flight parameters to be observed and the procedures to be followed in case of a failure,
- a meeting between the crew and the departments which participated in the flight preparation, organized within good time before the scheduled date of flight,
- effective reconnaissance of the place where the flight is to be made,

and if possible :

- one or more practice flights on a representative flight simulator including special attention to the critical aspects which may result from non-observance of the flight parameters, especially in case of a failure.

4.1.2 - The presence of passengers on-board, provided for in the charter contract for this flight, contributed, during the accident, to the aggravation of the consequences for the persons.

The Investigation Commission recommends that :

- this type of flight (participation in air shows) be made without passengers and with minimum crew including only the persons required to carry out the flight, the only manoeuvres authorized with passengers on-board being those laid down in the operating manual.

4.1.3 - The Commission remarked that the internal Air-France note DOND 50420 laid down certain rules which were not in compliance with regulations.

The Commission recommends :

- that the internal rules of the airlines be checked for conformity with official regulations.

4.2 - TRAINING OF PERSONNEL

4.2.1 - Flight crews

4.2.1.1 - The Investigation Commission remarked that the pilots planned to carry out a manoeuvre at the limits of the flight envelope and that the role of each crew member had not been precisely planned.

The Commission recommends that :

- airline pilots be reminded that their job consists of strictly applying standard and well-defined procedures ;
- consequently, their training be more oriented towards safety which requires that standard flight conditions be permanently maintained ;
- for the A320 training in particular, the pilots are made aware that the performance limitations still stand, as on any other aircraft, in spite of the many automatic protections (especially with respect to stall and wind shear) ;
- for flights made with crew members of the same rank, the functions of each and the task sharing be especially well defined.

4.2.1.2 - The investigation showed that neither of the crew members had previously made demonstration flights nor followed specific training for this.

The Commission recommends that :

- crews performing demonstration flights receive special and well-adapted training, which is not within the scope of the basic training or type qualification.

4.2.2 - Cabin attendants

4.2.2.1 - During discussions held with cabin attendants, whether or not involved in the accident, it became clear that after the A320 specialization training course, certain cabin attendants still had doubts relevant to certain communication and safety equipment, these doubts being alleviated only after in-service practice from explanations given by other personnel and practical training on the aircraft during line stops.

The Commission recommends that :

- the aircraft qualification stage be reinforced and that emphasis be placed on the location and the use of the safety equipment (emergency exits, communication system, megaphone, anti-smoke masks, etc.). Each trainee must handle all the safety equipment on the actual aircraft or on a demonstration mock-up.

4.2.2.2 - The evacuation was achieved better at the rear than at the front of the aircraft. The experience of the cabin attendants present, who had already had experience of a similar situation, no doubt contributed significantly.

The Commission recommends that :

- means of simulating a realistic environment for training cabin attendants be studied.

4.2.2.3 - Several passengers said in their statement that the confidence of the cabin attendants and their reassuring words helped them to evacuate the aircraft rapidly and calmly.

The Commission suggests that :

- cabin attendants be made more aware of the psychological effect that their remarks and behaviour can have on the passengers.

4.3 - AIRCRAFT

4.3.1 - The Commission remarked that certain operating defects, which played no part in the accident (defects mentioned in the mechanical reports), have since been corrected on the in-service aircraft. The Commission believes therefore that no recommendations need be made concerning these.

4.3.2 - The Commission remarked that the aural announcements made by the radio altimeter and the aural warnings were transmitted only via the cockpit loudspeakers and not via the pilots' headsets.

The Commission recommends :

- that studies be made to see if it would not be judicious to transmit all warnings and aural announcements via the pilots' headsets.

4.3.3 - During the accident, the two recorders stopped almost simultaneously before the aircraft finally came to rest and was destroyed by the fire : the exact cause of this could not be determined, however, the most probable supposition is that the power supply cables of the 2 recorders broke. They are located in the same cable bundle.

The Commission recommends that :

- when these are separate voice and flight data recorders, the cable routes should also be separated.

4.3.4 - Due to the circumstances of the accident, the communications equipment was not used. However, study of the cabin furnishing reports and discussions with various cabin attendants led the Commission to recommend that :

- the system attaching the handset to the cabin wall be reinforced.

- the cabin interphone and the Cabin Attendant/Flight Crew/Cabin Attendant Call system be returned automatically to the "Public Address" function each time that the handset is hung up on its support, so that the flight attendants can broadcast urgent messages very quickly to the passengers using only one hand (at present, the system is reset after each use, two operations are therefore required to talk : select required function then press handset switch to talk).

Also, the Commission remarked that the emergency lighting automatic illumination programming error has been corrected ; they therefore consider that no recommendations relevant to this are required.

4.3.5 - In their response to the evacuation questionnaire, 11 passengers indicated that they had had some trouble in opening their seat belts and that some required help ; these difficulties were due to a lack of knowledge of the seat belt opening procedure.

Also, it must be noted that, to open this type of belt, the flap must be raised then the two halves of the belt separated.

Consequently, the Commission recommends that :

- during the safety demonstrations before each flight, use of the seat belt be demonstrated (closing, tightening, opening).
- these procedures be also indicated in the leaflet giving safety instructions for the passengers.
- the attention of the seat belt manufacturers be drawn to the advantage of providing unlocking systems where a single simple action causes both unlocking and separation of the two halves of the belt.

4.3.6 - From among the passengers who answered the questionnaire mentioned above, 50% (i.e. 49 persons) declared that they hit their head on the back of the seat in front of them leading, for some, to partial loss of consciousness.

The Commission recommends that :

- studies be undertaken so that the design of future seats takes this potential problem into account.

4.4 - ORGANIZATION OF HELP

After the accident, the fire fighting and first aid vehicles had difficulties in getting to the accident area, the only access road to the place where the air show was held (and also the place of accident) being congested by many private vehicles.

Also, the fire-fighting trucks could not gain access to the wreckage as they were too wide for the forest tracks, and only small vehicles could reach the aircraft.

The investigation commission recommends that : when air shows are organized :

- access to the aerodrome is kept open for fire-fighting and first aid vehicles,
- the safety facilities in-situ be adapted to the environment.

5 - APPROVAL OF THE REPORT

This report has been accepted unanimously by the members of the Investigation Commission, November 30th 1989.

President of the Commission

Claude BECHET

Vice-President of the Commission

François GONIN

L'Ingénieur Général de la
Météorologie

Bernard FARIHOUAT

Le Médecin Général Robert AUFFRET

L'Ingénieur en Chef
de l'Aviation Civile

Paul ARSLANIAN

Pilot Inspector,
Member of the Organisme
du Contrôle en Vol

Philippe GOURGUECHON

L'Ingénieur du Bureau
Enquêtes Accident

Jean-Paul de VILLENEUVE

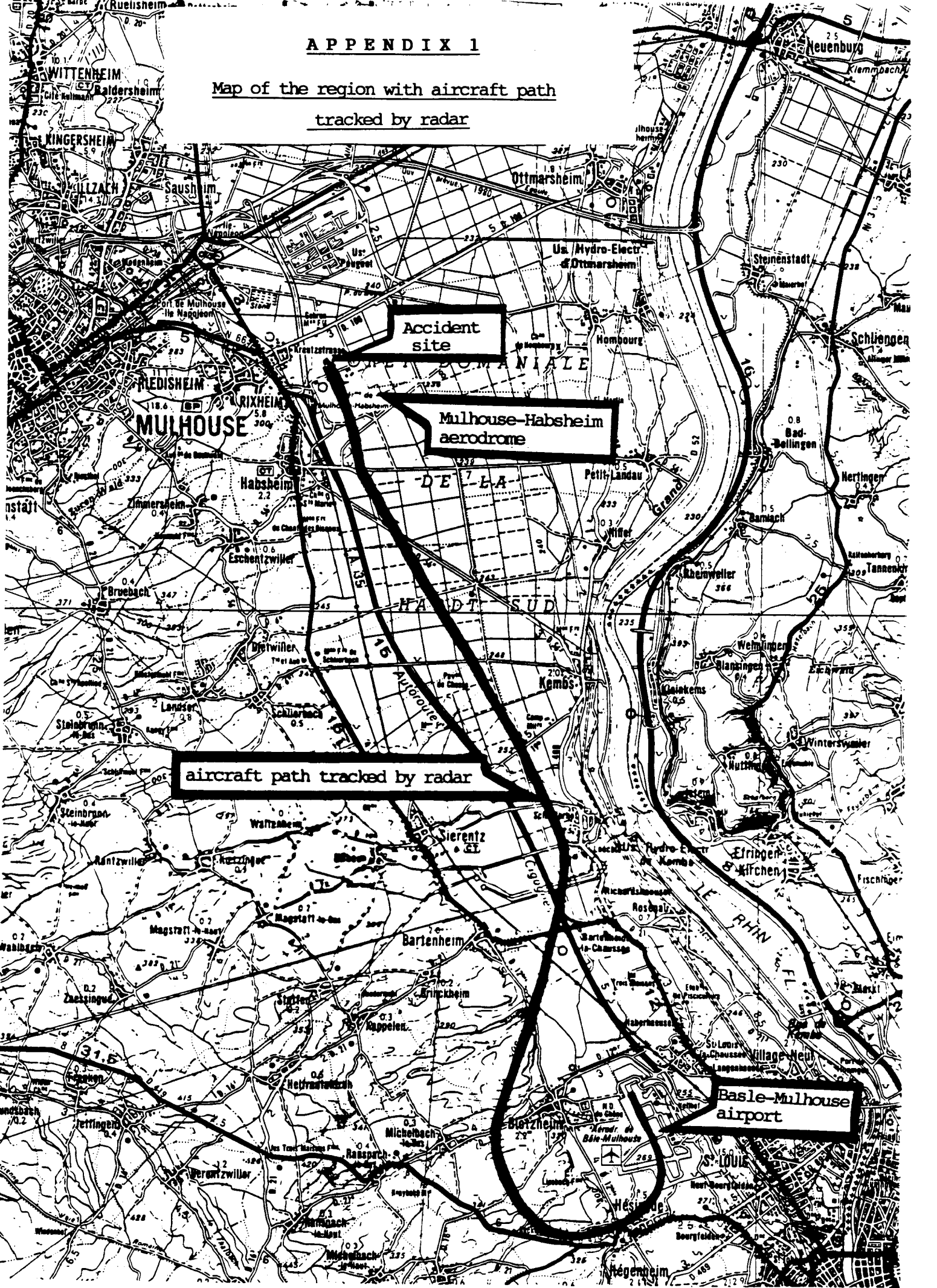
A P P E N D I C E S

-:-

- 1 - Map of the region with path tracked by aircraft radar
- 2 - Plate of the Mulhouse-Habsheim aerodrome
- 3 - Photographs
- 4 - Perspective view showing the way the trees were cut
- 5 - Transcript of the radio communications
- 6 - CVR transcript
- 7 - DFDR-CVR correlation
- 8 - Reproduction of DFDR parameters
- 9 - Air France Note DO ND 50420
- 10 - Flight Test Sheets

APPENDIX 1

Map of the region with aircraft path
tracked by radar



Accident site

Mulhouse-Habsheim aerodrome

aircraft path tracked by radar

Basle-Mulhouse airport

APPENDIX 2

- Mulhouse-Habsheim aerodrome plate -

- : -

CARTE D'ATERRISSAGE A VUE

MULHOUSE-Habsheim LFGB

Lat : 474417 N Long : 0072558 E

Alt 240 m - 787 Ft

FRANCE - 68 - HAUT-RHIN

Situation : 8 km E de Mulhouse

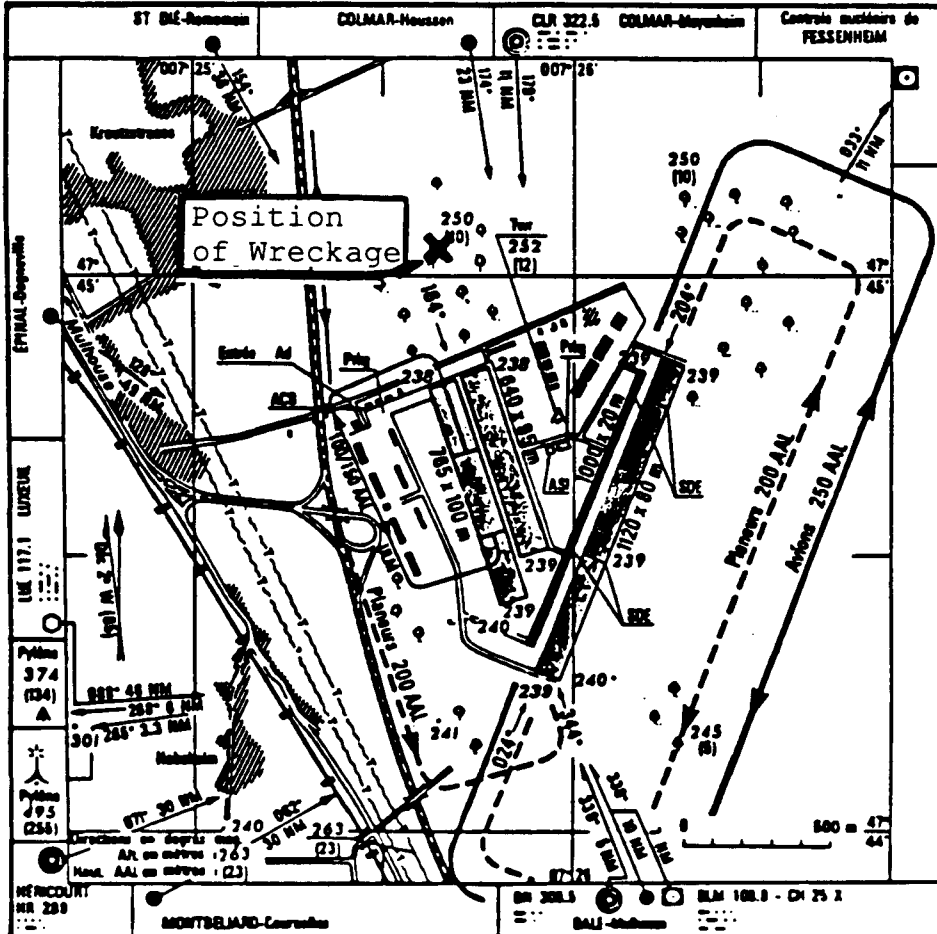
(28 hPa)

FIR : Paris

ACC : REIMS Information 124.100 - REIMS Coverble 124.950

App : NR

Twr : MULHOUSE Tour 125.250



Restrictions d'utilisation : Ad autorisé aux Ach non munis de radio sauf communication chef Ad. Utilisation autorisée pistes 024/204 autorisée. Lqj OFU 024 L : 835 m - Lqj OFU 024 R : 700 m - Lqj OFU 204 L : 800 m - Lqj OFU 204 R : 820 m
 Utilisation autorisée pistes 184 L 344 R et 184 R/344 L autorisée, exclusivement pendant Hor ATS pour Ach basés
 ULM réservé aux pilotes et ULM autorisés par chef Ad. Planeurs sans basés, s adresser au chef Ad.

Consignes particulières : Hors Hor ATS : par vent inférieur à 2 m/s, utiliser la OFU 204.
 Intégration dans le circuit après verticale ASI 300 m AGL.

Croix en vol figurée sur le carte. Éviter le survol de Rixheim et de Habsheim.
 TX04 OFU 204 : alignement au seuil de piste (casse naissance)

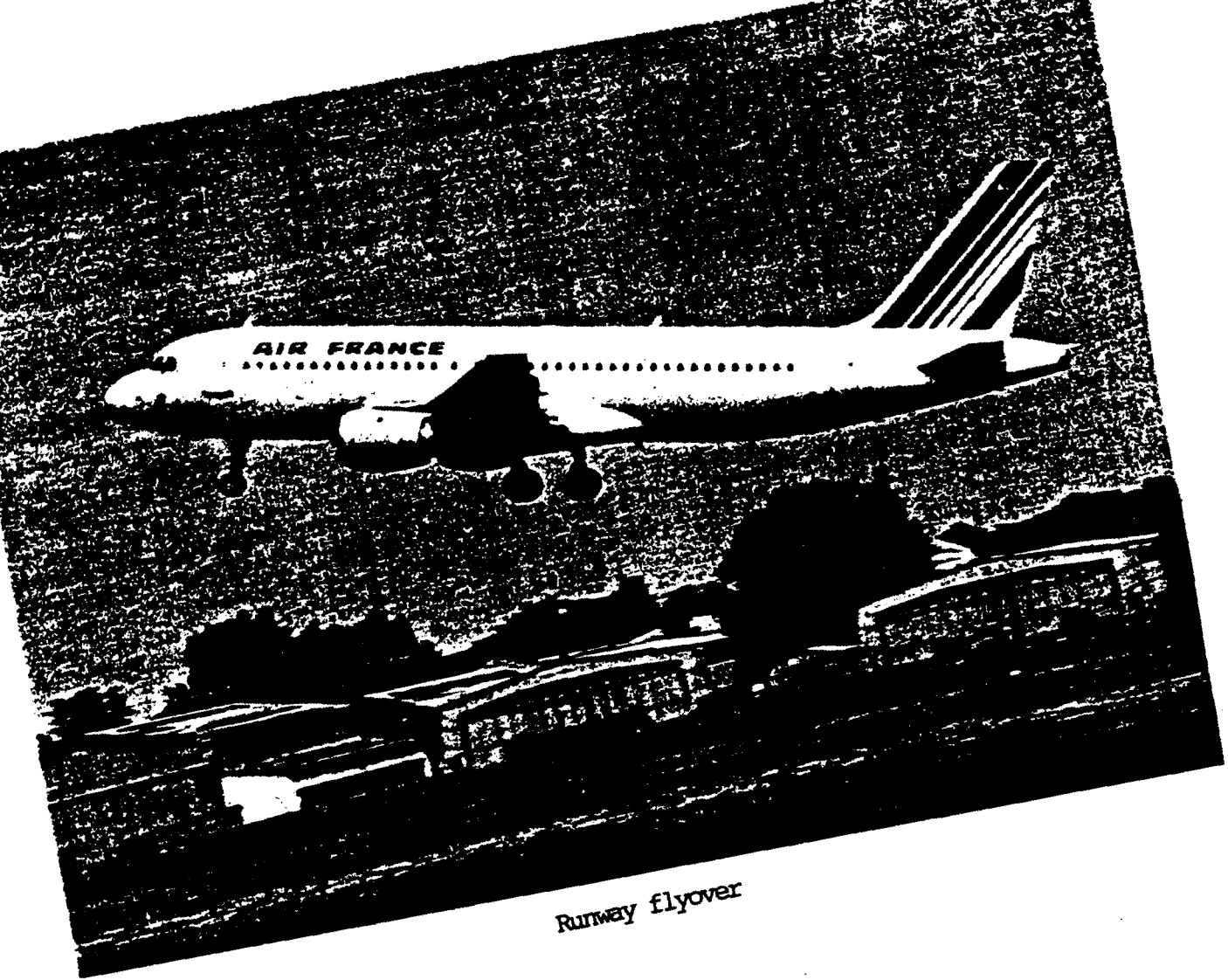
Renseignements complémentaires : Inutilisable hors pistes et Tour
 Aéromodélisme situé à l'Est de l'Ad.
 Ad situé sous l'ATZ Blâle-Mulhouse FL 050/300 m AGL.

CORRECTIONS : Restrictions - Consignes - Activités - ACB
 SERVICE DE L'INFORMATION AERONAUTIQUE — FRANCE

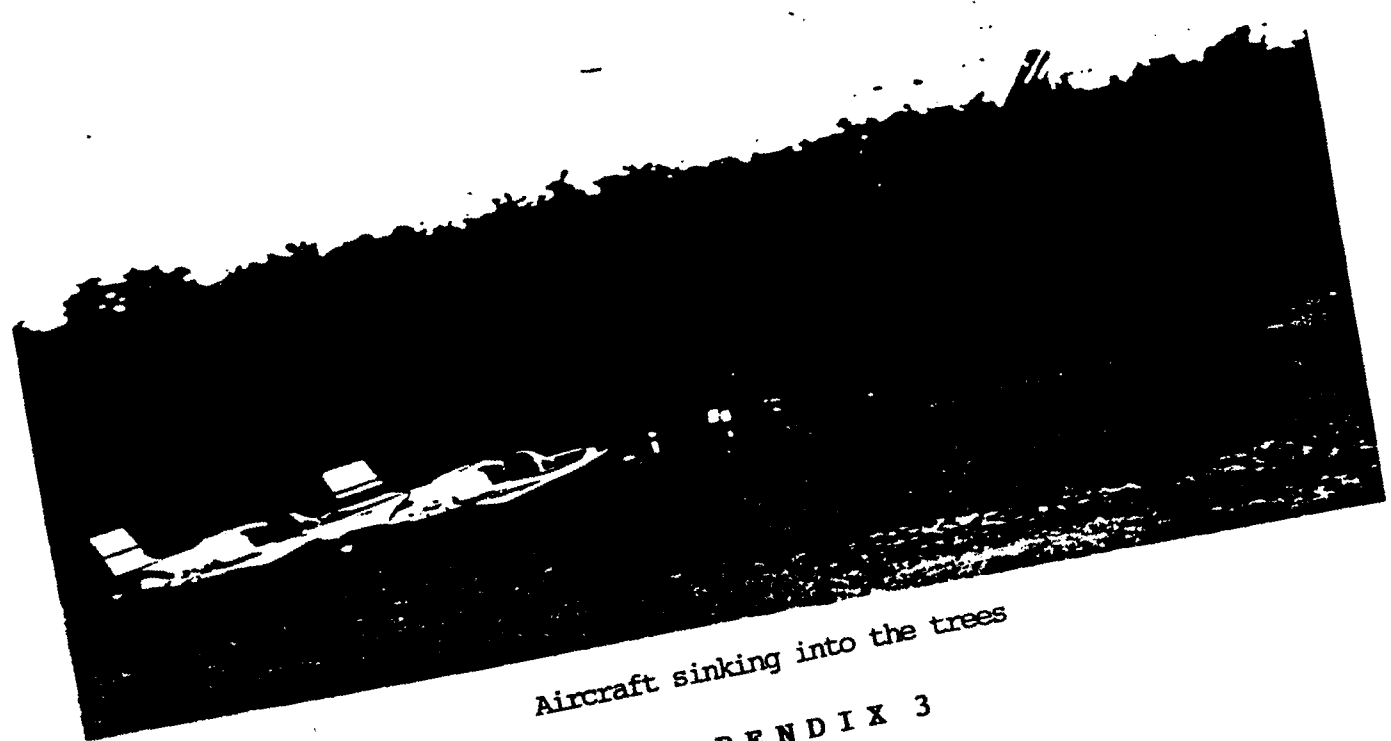
Nr 168 S 88 02 11

MULHOUSE-Habsheim LFGB

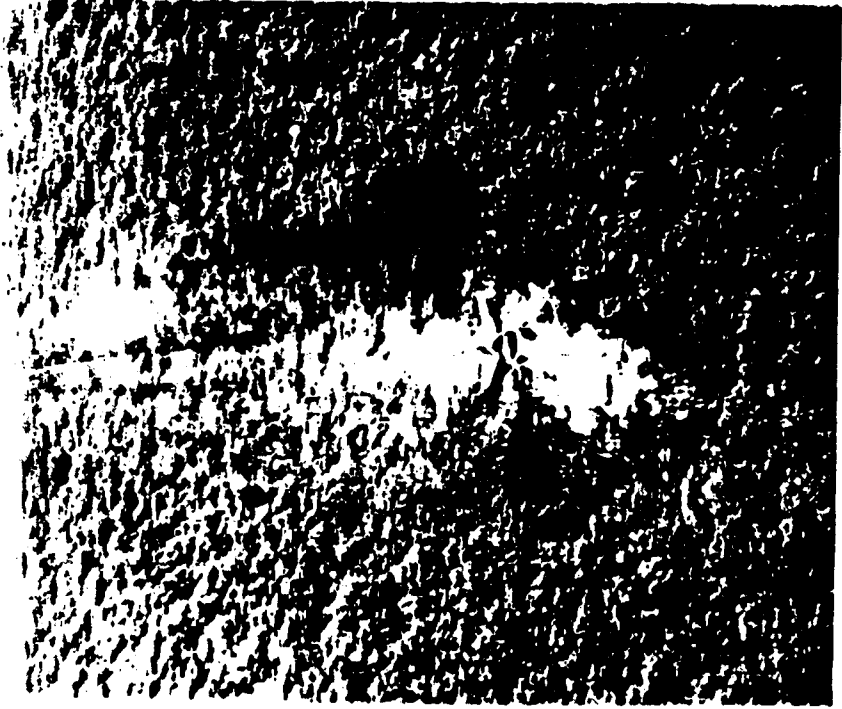
Reproduction interdite



Runway flyover



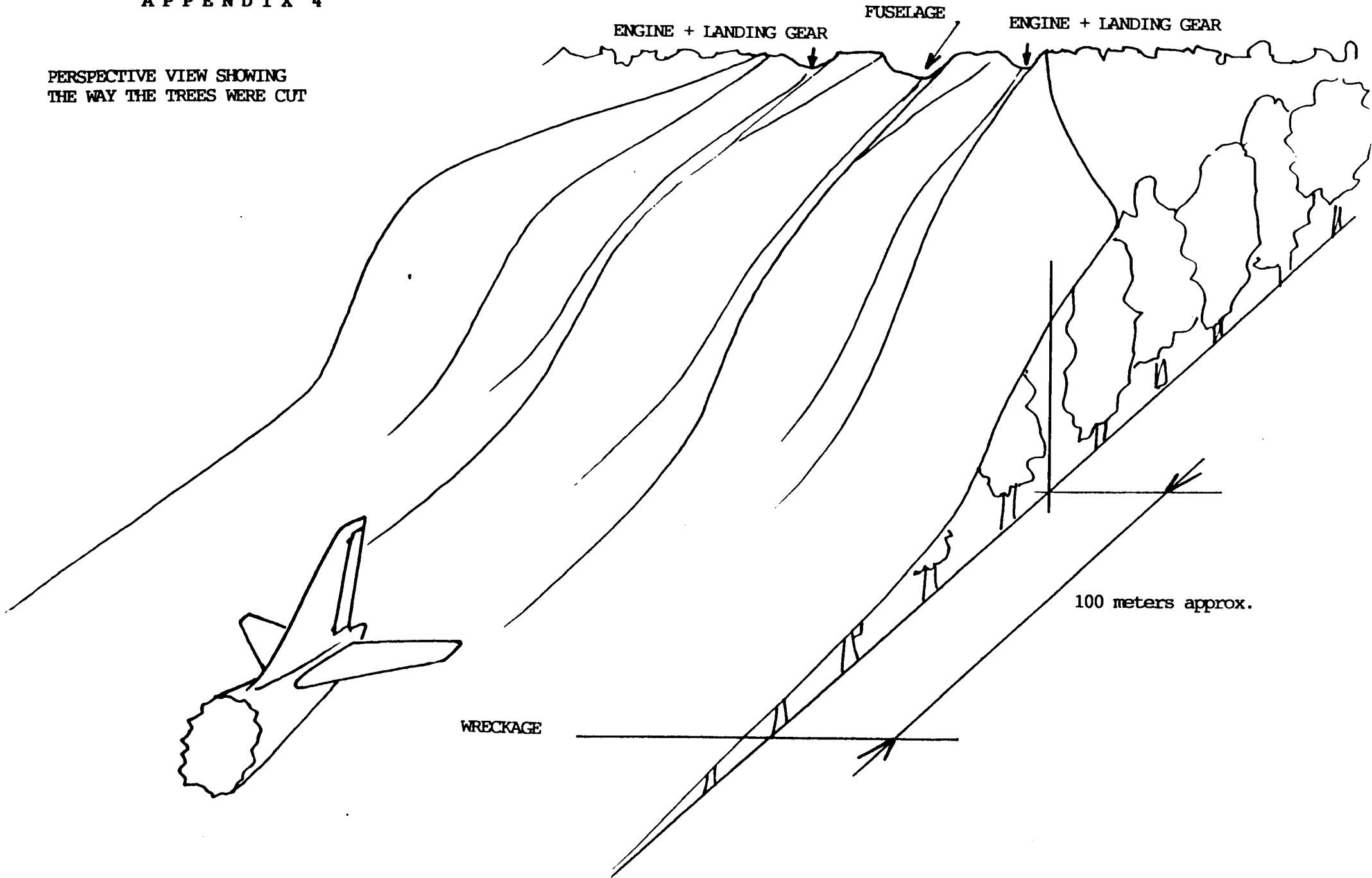
Aircraft sinking into the trees



Trees cut by the aircraft

APPENDIX 4

PERSPECTIVE VIEW SHOWING
THE WAY THE TREES WERE CUT



A P P E N D I X 5

RADIOCOMMUNICATION RECORDINGS
 BETWEEN BASLE-MULHOUSE AND ACF 296 Q
 ON JUNE 26th 1988

Time GMT	Stations		Text
12h 25m 00s	ACF296Q	-	Basle from Air charter two nine six
25m 04s	Basle	-	Air charter two nine six over
25m 06s	ACF296Q	-	We request start-up clearance
25m 08s	Basle	-	Roger two nine six I'll call you
25m 10s	ACF296Q	-	Roger
12h 25m 15s	Basle	-	Air charter two nine six clear to start up
25m 18s	ACF296Q	-	OK two nine six
12h 25m 24s	Basle	-	Two nine six confirm that on departure you're doing a flyover at Habsheim
25m 27s	ACF296Q	-	That's right so if it is OK by you we'll do anti-noise procedure on sixteen turn right fly towards BLM then straight to Habsheim and then leave for Hericourt as normal flight plan
25m 37s	Basle	-	Roger you are taking sixteen
25m 40s	ACF296Q	-	Roger that's fine thank you
12h 29m 12s	ACF296Q	-	Charter .. air charter two nine six taxi clearance please
29m 20s	Basle	-	Air charter two nine six Quebec taxi holding point sixteen
29m 23s	ACF296Q	-	For holding point sixteen air charter two nine six Quebec
12h 30m 50s	Basle	-	Charter two nine six Quebec can you tell what altitude you want

12h 31m 09s	Basle	-	Air charter two nine six Basle
31m 11s	ACF296Q	-	Go ahead
31m 12s	Basle	-	Two nine six Quebec can you tell me what altitude you want
31m 17s	ACF296Q	-	Yes after take-off we'll take a right turn one thousand feet to the flying club then there we make two flyovers. The second at high speed and then we'll negotiate clearance with you to go straight to Hericourt
31m 35s	Basle	-	Roger two nine six Quebec
31m 39s	ACF296Q	-	Well it would be good if we could have clearance before second flyover as we'll be passing at high speed like that we could climb quickly
31m 45s	Basle	-	Two nine six Quebec you confirm one thousand feet above ground then
31m 48s	ACF296Q	-	One thousand feet above ground and by right turn there and then after we'll descend for low altitude flyover of the airfield over there
31m 53s	Basle	-	Roger I'll contact you
31m 55s	ACF296Q	-	Roger
12h 32m 40s	Basle	-	Air charter two nine six Quebec ready to copy
32m 42s	ACF296Q	-	Go ahead
32m 43s	Basle	-	OK two nine six Quebec after take-off on sixteen right turn to Bravo Sierra climb to two thousand feet QNH one thousand and thirteen QNH and transponder six four four three
32m 55s	ACF296Q	-	Roger six four four three right turn to Bravo Sierra from Bravo Sierra and two thousand feet QNH air france oh sorry air charter two nine six Quebec eh then we go straight to the flying club and flyover over going north at low altitude and then the second flying south towards you and at that time we need one nine zero clearance to Hericourt
33m 23s	Basle	-	Roger and clearance will be regiven by approach therefore it's correct contact tower on one one eight three good-bye
33m 28s	ACF296Q	-	One one eight three good-bye two nine six Quebec

12h 34m 55s	ACF296Q	-	Air charter two nine six Quebec at holding point sixteen
34m 58s	Basle	-	Hello air charter two nine six Quebec hold before runway sixteen
35m 02s	ACF296Q	-	OK we're holding before runway sixteen
12h 36m 10s	ACF296Q	-	Two nine six Quebec we'll line up when you like
36m 14s	Basle	-	Two nine six Quebec hold before runway sixteen we still have an IFR to land, like that you can go straight to Habsheim at low altitude
36m 20s	ACF296Q	-	Thank you two nine six Quebec we hold
12h 38m 34s	Basle	-	Air charter two nine six Quebec a cityliner on final sixteen call when you see it
38m 38s	ACF296Q	-	Roger we can see it two nine six Quebec
38m 40s	Basle	-	Roger behind the cityliner on final sixteen line up behind and hold
38m 43s	ACF296Q	-	OK behind the aircraft on final we line up and hold two nine six Quebec
12h 40m 40s	Basle	-	Air charter two nine six Quebec clear for take-off runway sixteen wind calm
40m 44s	ACF296Q	-	Rolling two nine six Quebec
12h 43m 34s	ACF296Q	-	After take-off for air france we're practically in sight of the airfield there
43m 41s	Basle	-	Roger air charter two nine six you can contact Habsheim on one two five two five good-bye
43m 45s	ACF296Q	-	One two five two five good-bye

END OF RECORDING

TRANSCRIPTION OF RADIOCOMMUNICATIONS EXCHANGED
ON JUNE 26 1988 ON FREQUENCY/125.250 MHz

P = Pilot A/C ACF 296 Q

C = Mulhouse-Habsheim controller

UTC

1244	P	Air Charter Quebec Hello
124404	C	296 Q Hello
	P	We're coming into view of the airfield for flyover
	C	Yes I can see you, you're cleared, sky clear
124415	P	OK we're going in for the low altitude low speed flyover Air Charter Quebec
	C	Roger
124425	C	Quebec November Hotel Habsheim 1012 Fox Echo 984
	P	Roger
		Call Fox Alpha Bravo Quebec
124551		(not identified) : Achtung Feuer Feuer the 320 the 320 has caught fire Achtung Achtung
1246	C	Basle Basle the 320 has crashed the 320 has crashed
	Basle	You repeat, it has crashed
	C	Affirmative 34 200 meters 300 meters north of the runway
	Basle	North of your runway
	C	Repeat
124616	UG	Alouette Uniform Golf, I'll take off for AEROMEDICAL EVACUATION if you like

	C	OK
	Basle	Basle Approach repeat Mulhouse here Basle Approach repeat where did the AIRBUS crash
124625	C	Affirmative it crashed north of the airfield after flyover
124630	Basle	North of the Mulhouse-Habsheim airfield
	Basle	How many kilometers about
124641	C	Try to warn the airport if you can send someone
124643	Basle	Roger all right we'll do what we have to then
	C	OK

A P P E N D I X 6

TRANSCRIPTION OF THE COCKPIT VOICE RECORDER
AND WARNINGS OF THE AIRBUS A 320 AIRCRAFT registered
F-GFKC involved in the accident on June 26th 1988
at MULHOUSE-HABSHEIM.

(FLIGHT ACF 296 Q)

--:--:--:--:--

KEY

Capt. : Captain
F/O : First Officer
Purser : Purser
Feminine Voice
TOWER : Local aerodrome control tower
GROUND : Line mechanic
... : Word, Group of words, not understood or
omitted

REMARKS

Only the last 19 minutes of the CVR have been transcribed as only these concern the flight during which the accident occurred. They have been subjected to a spectral analysis which was more exhaustive for the last 36 seconds. Therefore, the conversations, have been accurately identified and timed in this transcription.

TIME	FROM	CONVERSATIONS	RADIO	NOISES WARNINGS COMMENTS
<u>Remark : Start of tape corresponds to end of previous flight (not transcribed)</u>				
12 H 27'15''	GROUND Capt.	Good OK ready for push back then OK		Click !
12 H 27'32''	Capt. GROUND Capt.	Ready for start-up of 1 OK Roger		
12 H 27'37''	Capt.	you see 1 how it got it there are 2 signals, there's boost APU which gives the signal and closure of packs, the packs they've already got their signal as well When we start		Whoop... Whoop... Whoop
12 H 27'46''	Capt. Feminine Voice	There's a prehistoric one ! -----		(Laughter and jokes concerning a first generation aircraft arriving at adjacent parking area).
	F/O	OK, Ignition A and oil pressure		Click ! Personal discussion
12 H 28'11''	Capt.	OK, start-up completed you can unplug and signal on left I think good-bye !		Gong !
12 H 28'17''	GROUND Capt.	OK, good trip, see you later, Yeah ! Adios mate Right away, got to do it, Click, Click You press it Hop ! There ! Sorry, thank you		Gong ! (doubtful) Click ! Click ! Many switching noises Click ! Click !

12 H 28'33''	Capt.	Control surfaces clack ! clack ! Like that I'll hear you
	F/O	Yes but
	Capt.	There you are, do you want to try ?
	F/O	It's very good...
12 H 28'46''	Feminine Voice	You managed to find a mechanic after all !
12 H 28'50''	Capt.	After start check list
	F/O	"After start" Ignition !
12 H 28'53''	Capt.	NORMAL !
	F/O	ECAM Status. They're there !
	Capt.	They're there and we know them Click All black
12 H 29'01''	F/O	OK
	F/O	Anti ice ?
	Capt.	OFF !
12 H 29'04''	F/O	Gen 1 and 2 ?
	Capt.	ON !
	F/O	Flight controls ?
	Capt.	Checked !
	F/O	On right as well ! Rudder trim !

(blowing twice into the
microphone)

(Laughter)

	Capt.	It's at zero !
12 H 29'10''	F/O	and the pitch ?
	Capt.	Everything's fine
	F/O	.. You checked everything it's OK ? "After start" completed !
12 H 29'13''	F/O	We are on one That's OK
	F/O	Wait, I'll do it, I'll speak
	Capt.	OK
12 H 29'16''	F/O	
12 H 29'20''	TOWER	
12 H 29'23''	F/O	
12 H 29'26''	Capt.	Right ?
	F/O	All clear to right ! ----- -----
	F/O	Eh, we've not extended flaps 1 !
	Capt.	One We have, it's OK !
12 H 30'13''	F/O	and spoilers armed !
	Capt.	There we are Anyway it's there for that it'll tell you.

- ACF 296 taxi
clearance please?

- ACF 296 Q taxi to
holding point 16

For holding point
16 the Air Charter
296 Q

Laughter and jokes
concerning previously
mentioned "prehistoric"
aircraft - Clack !

Clack !

12 H 30'16''	F/O	OK, you, you, you... you explain your speed, altitude, etc.	
12 H 30'20''	Capt.	OK then, take-off right turn, leave the flap at 1, anyway we do normal take-off, retract the landing gear and with flaps at 1, we go nice and easy to find our thing. As soon as we have formally identified it, we extend the flaps to 3, landing gear extended, do the flyover at 100 feet, landing gear out and then you leave it to me. I'll give it alpha max, I'll disengage the alpha floor and then, if I tell you it is hard you help me and you hold the power to keep zero vertical rate	
12 H 30'51''	TOWER	Zero vertical rate and me I'll hold it at alpha max. At the signal you give it TOGA and I'll pull the stick and if you're there I bank away	- ACF 296 Basle, can you tell me what altitude you would like ?
12 H 30'56''	F/O	You want to get off there then ?	
	Capt.	That, I've done it twenty times, that one.	
	F/O	OK, we're agreed !	
12 H 30'59''	Capt.	And then, after, we bring everything in, move off and give it all its got to 340 knots and the second, you also go over at 100 feet, and there, no need to pull 2.5 g as back there, they won't like it.	
12 H 31'09''	F/O	OK all that	
12 H 31'09''	TOWER		ACF 296 Q Basle ?
12 H 31'11''	F/O		Go ahead !
12 H 31'13''	TOWER		Yes, 296 Q, can you tell me what altitude you want ?

	F/O	2000 ?	
12 H 31'18''	Capt.	Roger, 1000 feet to get there get there, 1000 feet ground	1000 feet to
12 H 31'19''	F/O		Yes, after take-off, we'll take a right turn 1000 feet to the flying club then there we'll make 2 flyovers the second at high speed and then we'll negotiate clearance with you to go to hmmm
12 H 31'35''	Capt.	... Héricourt	Héricourt.
12 H 31'35''	TOWER		Roger 296 Q
	Capt.	So it's 1000 feet Fox Echo	
12 H 31'39''	F/O		Well, it would be good if we could have clearance before the second flyover as we'll be passing at high speed, like that, we could climb quickly
12 H 31'45''	TOWER		Roger, 296 Q, you confirm 1000 feet above ground then ?
12 H 31'49''	Capt.	1000 feet/ground	

12 H 31'49''	F/O		One thousand feet above ground and by right turn there, then we'll descend for low altitude flyover of the airfield there	Clack !
12 H 31'53''	TOWER		OK I'll call you	
12 H 31'55''	F/O		OK	Clack !
12 H 31'58''	Capt.	Autobrake max		
	F/O	Yes !		
	Capt.	Take-off config test		
	F/O	Yes then ! eh ! OK !		
12 H 32'03''	Capt.	Have you already seen what the take-off config test does... watch, if you put it there Wait there Wait sh.... Imagine that it's like that Go on the take-off config That's it it must move a little That's it, do it now ! Go on.		Clack ! Clack !
	F/O	...(reply incomprehensible !)		Clack !
	Capt.	Yeh Yeh		
	Capt.	Put it... put it on 1 so that we won't get it wrong.		
12 H 32'22''	Capt.	The detents are too well done		
12 H 32'25''	F/O	Well then ! Between the two there when I take it for the high speed flyover you negotiate the 190 clearance so that we can get out of there and do a pull-out at 2g for STS.		

12 H 32'35''	Capt.	No, don't pull-out at 2.5 g as yesterday we did 2 g 2.5 g in training and I've had enough of that I have	
12 H 32'40''	TOWER		ACF296, ready to copy ?
	Capt.	- Yes, he's ready !	
12 H 32'42''	F/O		Go ahead !
12 H 32'44''	TOWER		OK 296 Q after take-off on 16 right turn to Bravo Sierra climb to 2000 feet QNH, QNH 1013 and transponder 6443
	Purser	In short, what are we doing ?	
12 H 32'55''	F/O		Roger, then 6443 right turn to Bravo Sierra, from Bravo Sierra and 2000 feet QNH AIR FRANCE oh sorry...ACF 296 Q, eh then we go straight to the aeroclub. We flyby going north at low altitude and then second flyby southward towards you and at that time we need 190 clearance to Hericourt.
12 H 32'59''	Capt.	We take off, fly to the Habsheim airfield, there we do a low altitude flyover, bank, accelerate, flyover at top speed and get out of there.	
	Purser	to the..... Mont-Blanc ?	
12 H 33'16''	Capt.	A second flyby southward !	
12 H 33'23''	TOWER		Roger and clearance

12 H 33'26''	Capt.	There we are...	will be regiven by approach therefore it's correct contact tower on 118.3 good-bye	
12 H 33'29''	F/O		118.3, good-bye 286 Q	
	F/O	Yes, you were saying ?		Click !
	Purser	- No, but I was saying the cabin was ready...		
	F/O	You, you stay seated during the complete flyover...		
	Purser	About the announcements, you're doing something...		
12 H 33'38''	Capt.	I'm going to tell them, yes, The announcements I'll do them		
	Purser	... OK there are also some... in German.		
	F/O	You see		
12 H 33'43''	Capt.	Ladies and Gentlemen, Hello and welcome aboard this AIRBUS 320 No. 3 of the series for AIR FRANCE and which has only been in service for 2 days. We shall soon take off for a short tourist flight starting at the Habsheim flying club where we will do 2 flyovers to demonstrate the continuity of the French Aviation and then we shall make a tour of Mont-Blanc depending on the weather conditions and air traffic. I wish you a very agreeable flight. Meine Damen Und Herren.... Ich wüsche Ihnen eine Guten Flug.		(Announcement more or less identical in German)
12 H 34'47''	Capt.	There we are good		

12 H 34'55''	Capt.	...	ACF 296 Q at holding point 16	(Joke about the First Officer) ⁹
12 H 34'58''	TOWER		Hello ACF 296 Q hold before runway 16	
12 H 35'02''	Capt.		OK ! We're holding before 16.96 Q	
12 H 35'10''	Capt.	I'm going to give C... hell. He's not seen that the data banks are not the same. He's gonna be in the sh... for a while !		(Laughter)
	F/O	Alright !		
	Capt.	Poor C... he'll be in for it		
	F/O	Eh ! We've not done it before take-off !		
	Capt.	What before take-off we are... hold before runway.		Word incomprehensible
	F/O	Yes ! but it's done high up...		
12 H 35'25''	Capt.	Well, autobrake max,		
	F/O	Well, yes		
	Capt.	Signs on		
	F/O	Eh		
	Capt.	It makes no difference ; spoilers armed,		
	F/O	Eh yes If the it disengages just after the landing gear it's OK.		
	Capt.	Flaps 1, take off, take off config normal !		
	F/O	Normal ! Good "pre take-off" completed.		

12 H 35'42''	Capt.	Crate in view ! You're lucky aren't you ?		
	F/O	What did you say ?		Feminine voice
	Capt.	Super efficient Did you see that good work		
	F/O	Right on time every time ! Dead on time !		(jokes concerning journalists)
	Capt.	---		
12 H 36'10''	F/O		Ah... 296 Q We'll line up when you like	
12 H 36'14''	TOWER		296 Q hold before runway 16 we still have an IFR to land like that you can go straight to Habsteim at low altitude	
	Capt.	GUT !		
12 H 36'21''	F/O	GUT !	OK 296 Q we hold	(Whistling)
	F/O	Right then you we keep flaps 1 to go there and extend when we get there		
12 H 36'29''	Capt.	Wait take it easy, we descend, we've not much margin Cling ! gling ! gling !		
	F/O	Then... eh you you turn above there fly almost back over the end of the runway, pick up the motorway		(Whistling)
	Capt.	I've I've I've I've		
	F/O	and you almost didn't have it opposite		

	Capt.	and I've I've all here !	
	F/O	I'm like that !	
12 H 36'45''	Capt.	I'm not really worried about that you know	(Whistling)
12 H 36'54''	Capt.	I'll put it on NAV, like that I've an overall view and I stay on "ARC" - You put it on fort twenty forty twenty miles, so that all's in, me I'll stay on ARC at ten miles.	(Whistling)
	Feminine Voice	(Question inaudible)	
	Capt.	What ? No, I'll tell you something you're not used to cockpits, are you ? but like this when we're really busy as you can see you should not speak eh shouldn't bother not speak eh shouldn't bother the pilots, eh ?	
12 H 37'32''	Capt.	You see how he is !	
	F/O	... You are not used to	Discussions with the two passengers in the cockpit
	Capt.	-----	
	Feminine Voice	-----	
	F/O	-----	
	F/O	Have you seen what I've selected there ?	Personal conversation
12 H 38'15''	Capt.	Can you remember the clearance over the motorway ? eh ? eh ! Herr Mazières What is the minimum clearance over a motorway? Three hundred meters !	
12 H 38'24''	F/O	Eh ! And when we get over, Meribel, a little before I'll give you the microphone behind to call who you want there.	

	Capt.	We won't see it very well I don't you think so ?	
	F/O	What ?	
12 H 38'34''	TOWER		ACQ 296 Q, a cityliner final sixteen call when you see it
12 H 38'38''	F/O		Roger, we have seen it 296 Q
12 H 38'39''	Capt.	I don't know if you'll be able to see	
12 H 38'40''	TOWER		Roger behind the cityliner on final 16 line up behind and hold
12 H 38'43''	F/O		OK behind the aircraft on final we line up and hold 296 Q
	Feminine Voice	-----	
12 H 38'45''	Capt.	I'll flyover the runway there for eh flat out	
	F/O	no, no, no, no, don't pass I no, no	
	Feminine Voicewe've	
	Capt.	The radio's OK, that's that's it...	
	F/O	That what I want to say... on the radio what !	
	Capt.	Mustn't do just anything...	

	F/O	That for that you need a special clearance to do what you're going to do but at Meribel...	
	Capt.	No at Meribel there's not...	
	F/O	Otherwise I'm not going	
	Capt.	If I haven't got clearance we're not going ... there, the flyover, the only thing, is at the discretion of the crew...	
12 H 39'03''	F/O	There you know you if there you know anyway you'll get them on the radio eh we'll say... -----	(Jokes)
	F/O	OK, we line up behind	(Laughter)
12 H 39'39''	Capt.	You'll extend the lights and will keep them so that they can see us All the lights we keep them we'll retract them only passing	Clack ! Clack !
	Capt.	Ah... leave it on ...	(whistling)
	F/O(illegible)	
12 H 39'52''	Capt.	"WING" they won't see there's no point	
	Capt.	In any case, we'll forget them on landing	
	F/O	Yeah OK !	
12 H 40'16''	Capt.		(Sigh, whistling and German rhyme)

	Capt.	All right then, ready sir		
12 H 40'40''	TOWER		ACF 296 Q, clear for take-off runway 16 wind calm	
12 H 40'44''	F/O		We're rolling 296 Q	
12 H 40'48''	Capt.	Take-off Go		Engine acceleration noise
12 H 40'59''	F/O + Capt.	Thrust SRS ! RUNWAY		
12 H 41'04''	F/O	Parameters normal		Clack Clack
	Capt.	Gut		
12 H 41'16''	Capt. +	100		(simultaneously)
	F/O	100		
12 H 41'19''	F/O	It's already requesting "CLIMB" the b....., you see that ?		
	Capt.	Yeah, that happens I know the bug		Illegible
	F/O	Yeah yeah		
12 H 41'26''	F/O	V1 - Vr		
	F/O	It wasn't up		Doubtful
12 H 41'32''	Capt.	Positive climb Gear up		Clack ! (L/G operation)
12 H 41'47''	F/O	Alt Star Gear up		(Buzzer) (Alt capture)
12 H 41'52''	Capt.	Gear up ?		(Reduction in engine noise)

12 H 41'56''	F/O	Gear up, flaps 1, after take-off check list is completed except for flaps	
12 H 41'58''	Capt.	I'm dis...gaging the autothrottle	(word not clear)
12 H 42'00''			Gong = Instinctive Disconnect (declaration by crew)
			Clack... Clack... Repetitive gong (config. warning)
12 H 42'03''	Capt.	That's the landing gear that, it's not important, kill it eh	
	F/O	
12 H 42'06''	Capt.	It's below 1000 feet at low altitude you can be sure	Slight increase in engine speed
12 H 42'08''	F/O	Shall we extend it eh ?	
12 H 42'12''	Capt.	No ! No : don't extend right away, it's because I've throttled back to below a certain N.1. We know that one	Stabilization of engine speed
12 H 42'27''	Capt.	Oh ! kill it Ah ! It gets on my wick that one	(New repetitive gong !) (second config warning)

12 H 42'29'' F/O Extend it, it makes no difference to get there

12 H 42'32'' Capt. There we are...

12 H 42'54'' Capt. Good, it is as if we could see the airfield

F/O You're at 8 nautical miles there, you'll soon see it, there's the motorway

12 H 42'57'' Capt. We'll leave the motorway to left, won't we... it's to the left... no, to the right of the motorway.

F/O It's slightly to the right of the motorway so you... you leave the motorway on the left

12 H 43'07'' Capt. OK, as soon as we identify we descend very quickly then,

12 H 43'10'' F/O Leave everybody fastened in

Capt. That's, that's normal for it, it always does that to start with. You see, it keeps the landing gear the whole thing

Capt. OK, then it is OK ! that we've got at the start. Well there's a little way that's interesting. Yeah

12 H 43'36'' F/O

After take-off for Air France 296, we're practically in view of the airfield there

Reduction in engine speed

Clack

12 H 43'41''	TOWER		Roger ACF 296 you can contact Habsheim 125.25 good-bye	
12 H 43'46''	F/O		125.25 good-bye	
	F/O	Habzeim ? That's it no ?		
	Capt.	Habsheim. Habs Heim		
	F/O	Habsheim		
12 H 44'01''	F/O		Ah ! Habsheim Air Charter 296 Q Hello	
	Capt.	There's the airfield. It's there... you got it, have you ?		
12 H 44'05'	TOWER		296 Q Hello	
12 H 44'10''	Capt.	What ?	We're coming into view of the airfield for flyover	
12 H 44'13''	TOWER		Yes, I can see you, you're cleared eh Sky is clear.	Clack
12 H 44'15''	Capt.	Gear down		
12 H 44'17''	F/O		OK, we're going in for the low altitude low speed flyover 296 Q	L/G aerodynamic noises
12 H 44'22''	TOWER		Roger	
12 H 44'23''	Capt.	Flaps 2		Clack

12 H 44'27''	TOWER		QNH Habsheim 1012 Fox Echo 9.8.4.
	Capt.	OK	
12 H 44'31''	F/O		Roger
12 H 44'32''	Capt.	9.8.4. put in 9.8.4.	
12 H 44'34''	F/O	9.8.4. QFE selected !	
12 H 44'37''		Good gear is down ; flaps 2 !	
12 H 44'42''	Capt.	Flaps 3	
12 H 44'45''	F/O	Flaps 3 !	
	Capt.	That's the airfield, you confirm ?	
12 H 44'48''	F/O	Affirmative	
12 H 44'51''	F/O	You see it LL 01, when we get there there you're at 1 nautical mile, that's right	
12 H 44'55''	Capt.		GONG ! (Nose Wheel Valve according to the crew)
	F/O	OK !	"Too Low Terrain" (GPWS)
12 H 45'04'' 7/10			Gong ! (GPWS cut-off according to the crew)
12 H 45'05'' 7/10			"Two hundred !" (radio altimeter) allusion to airline flight safety officer
12 H 45'11''	F/O	P..... G.....!	

12 H 45'11'' 4/10			"Two hundred" (radio altimeter)
12 H 45'12'' F/O		G..... is going to... eh !	(continuation of previous personal remark)
12 45'14'' F/O		OK, you're at 100 feet there, watch, watch	
12 H 45'15'' 3/10			"One hundred" (radio altimeter)
12 H 45'19'' 1/10			"Forty" (radio altimeter)
12 H 45'23'' 6/10			"Fifty" (radio altimeter)
12 H 45'26'' Capt.		OK, I'm OK there, disconnect autothrottle	
12 H 45'27'' 5/10			"Forty" (radio altimeter)
12 H 45'32'' F/O		Watch out for the pylons ahead eh See them ?	
12 H 45'33'' Capt.		Yeah, Yeah, don't worry	
12 H 45'34'' 5/10			Clack ! Clack ! Clack ! (power lever detents)
12 H 45'35'' 3/10			"Thirty" (radio altimeter)
12 H 45'36'' 2/10			"Thirty" (radio altimeter)
12 H 45'37'' F/O		TOGA/SRS	
12 H 45'38'' 3/10			"Thirty" (radio altimeter)

12 H 45'39''

F/O

Go around track

12 H 45'39''
9/10

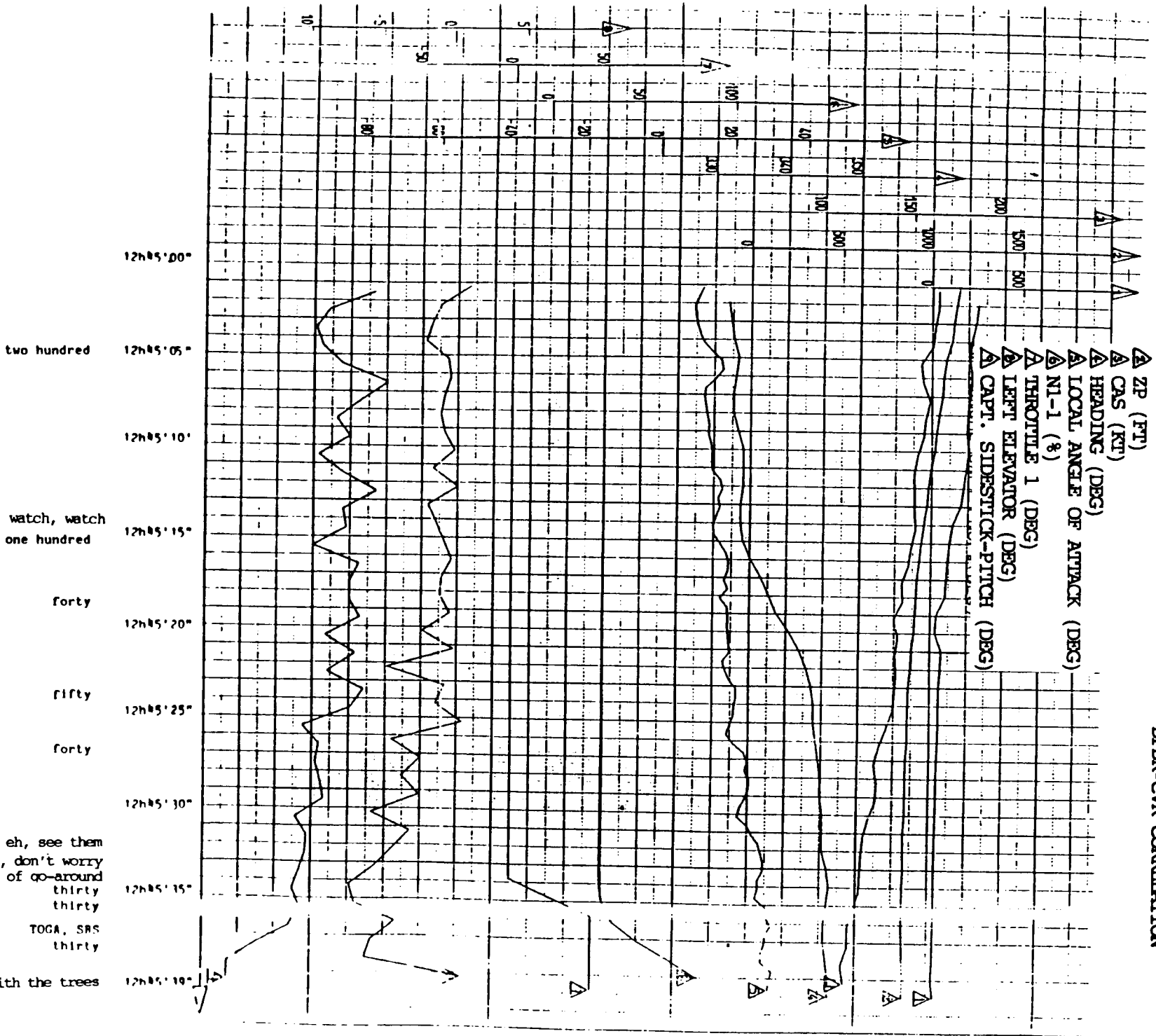
Capt.

Sh..... !

12 H 45'41''
5/10

END OF TAPE

Increase in engine
speed
Noises of impact in the
trees



two hundred

you arrive at 100 feet there, watch, watch one hundred

forty

fifty

forty

watch out for the pylons ahead, eh, see them yeah, yeah, don't worry initiation of go-around

thirty
thirty
TOGA, SRS
thirty

impact with the trees

A P P E N D I X 8

REPRODUCTION

OF DFDR

PARAMETERS

QTY	MESH	---ALTIMETER---				---VELOCITY---		CAP	TAT	---COMMANDS OF VOI---				---GOUVERNES---			ASSIETTE		INC					
		FI	FM	FF	FR	ST	SR			GAUCHI	DE	PROF	DIR	ATTENON	PROFONDUR	DIR	LAT	LONG			DEGRES	DEG		
1743	202,0	0117	01224	232	-0324	147	154	270		00	27	004	27	171	057	002	000	000	003	L01	L03	U01	+03	1
1744	202,0		01212	232	-0300	149	154	271	272	00	27	004	27	171	015	003	001	00	003	L00	L02	U00	+02	2
1744	202,0		01102	232	-0327	142	162	272		00	27	002	27	171	015	005	002	001	003	L00	L01	U01	+03	3
1744	202,0		01102	232	-0327	142	162	272	272	00	27	000	27	171	004	009	001	000	003	L01	R02	U02	+04	4
1744	202,0	0017	01174	232	-0320	143	163	272		00	27	000	27	171	001	004	001	001	003	L01	R04	U02	+05	1
1744	202,0		01174	232	-0320	143	163	272	272	00	27	006	27	171	001	011	001	002	003	L02	R02	U02	+04	2
1744	202,0		01150	232	-0321	143	150	272		00	27	004	27	171	000	005	001	000	003	L01	R00	U02	+03	3
1744	202,0		01151	232	-0320	143	150	272	272	00	27	003	27	172	002	006	001	002	003	L01	R01	U01	+03	4
1745	202,0	0011	01122	232	-0320	143	154	272		00	27	002	27	172	006	003	001	001	003	L00	R01	U01	+04	1
1745	202,0		01110	232	-0310	143	154	272	272	00	27	002	27	172	002	004	001	00	003	L01	R01	00	+02	2
1745	202,0		01108	232	-0310	143	154	272		00	27	000	27	172	006	004	001	001	003	L01	R01	00	+03	3
1745	202,0		01074	232	-0324	141	154	272	272	00	27	004	27	172	006	014	002	00	003	L01	R02	U01	+04	4
1745	202,0	0110	01062	232	-0320	143	154	272		00	27	002	27	172	002	005	002	000	003	L02	R02	U02	+07	1
1745	202,0		01054	232	-0320	145	152	272	272	00	27	000	27	172	002	001	00	003	003	L01	00	U02	+06	2
1745	202,0		01054	232	-0320	145	152	272		00	27	001	27	172	006	001	000	000	003	L00	L00	U02	+04	3
1745	202,0		01022	232	-0324	142	152	272	272	00	27	002	27	172	015	004	001	000	003	L00	R00	U02	+04	4
1745	202,0	0110	01012	232	-0320	145	150	272		00	27	000	27	172	006	004	000	001	003	L01	R01	U02	+05	1
1745	202,0		01004	232	-0320	143	152	272	272	00	27	002	27	172	006	005	000	000	003	L01	R02	U02	+05	2
1745	202,0		00972	232	-0324	142	149	272	272	00	27	001	27	172	006	005	000	000	003	L01	R01	U03	+05	3
1745	202,0		00972	232	-0324	142	149	272	272	00	27	005	27	172	001	004	00	003	003	L01	00	U02	+06	2
1745	202,0	0110	00956	232	-0314	141	144	272		00	27	002	27	172	001	004	000	000	003	L01	R01	U04	+07	1
1745	202,0		00924	232	-0320	141	146	272	272	00	27	002	27	172	010	006	001	002	004	L00	R02	U04	+05	2
1745	202,0		00924	232	-0320	141	146	272		00	27	003	27	172	011	001	002	000	004	L00	R04	U05	+07	3
1745	202,0		00902	232	-0324	140	144	272	272	00	27	002	27	172	017	001	000	000	004	L00	R05	U06	+09	4
1745	202,0	0000	00880	232	-0321	144	147	272		00	27	000	27	172	006	004	001	001	004	L00	R09	U06	+07	1
1745	202,0		00870	232	-0320	140	149	272	272	00	27	004	27	172	001	005	001	001	004	L00	R11	U06	+08	3
1745	202,0		00870	232	-0320	140	149	272	272	00	27	005	27	171	004	019	002	002	004	L00	R13	U05	+09	4
1745	202,0	0100	00852	232	-0324	141	144	272		00	27	000	27	172	000	004	000	002	004	L02	R09	U06	+09	1
1745	202,0		00822	232	-0321	141	146	272	272	00	27	006	27	172	002	017	004	002	004	L01	R07	U06	+08	2
1745	202,0		00820	232	-0325	141	143	272	272	00	27	002	27	172	001	005	000	000	004	L02	R05	U08	+09	3
1745	202,0		00820	232	-0325	140	142	272	272	00	27	002	27	172	001	009	001	000	004	L01	R03	U08	+09	4
1745	202,0	0100	00804	232	-0324	141	147	272		00	27	000	27	172	006	004	000	000	004	L01	R02	U08	+09	1
1745	202,0		00804	232	-0324	141	147	272	272	00	27	000	27	172	006	004	000	000	004	L01	R01	U08	+09	2
1745	202,0		00804	232	-0324	141	147	272	272	00	27	000	27	172	006	004	000	000	004	L01	R00	U09	+11	3
1745	202,0		00804	232	-0324	141	147	272	272	00	27	000	27	172	006	004	000	000	004	L01	R00	U09	+11	4
1745	202,0	0000	00786	232	-0325	141	146	272		00	27	001	27	172	006	002	002	004	004	L01	L00	U10	+11	1
1745	202,0		00786	232	-0325	141	146	272	272	00	27	001	27	172	006	002	002	004	004	L01	L00	U10	+11	2
1745	202,0		00786	232	-0325	141	146	272	272	00	27	001	27	172	006	002	002	004	004	L01	R01	U10	+10	2
1745	202,0		00786	232	-0325	141	146	272	272	00	27	001	27	172	006	002	002	004	004	L01	R01	U11	+12	3
1745	202,0		00786	232	-0325	141	146	272	272	00	27	001	27	172	006	002	002	004	004	L00	R01	U12	+14	4
1745	202,0	0100	00774	232	-0320	142	149	272		00	27	000	27	172	004	002	002	000	004	L01	R02	U12	+13	2
1745	202,0		00774	232	-0320	142	149	272	272	00	27	000	27	172	004	002	002	000	004	L01	R02	U12	+13	2
1745	202,0		00774	232	-0320	142	149	272	272	00	27	000	27	172	004	002	002	000	004	L00	R02	U13	+14	3
1745	202,0		00774	232	-0320	142	149	272	272	00	27	000	27	172	004	002	002	000	004	L00	R01	U14	+15	4
1745	202,0	0000	00762	232	-0320	141	147	272		00	27	000	27	172	005	003	000	000	004	L01	R01	U13	+14	1
1745	202,0		00762	232	-0320	141	147	272	272	00	27	000	27	172	005	003	000	000	004	L00	R01	U13	+14	2
1745	202,0		00762	232	-0320	141	147	272	272	00	27	000	27	172	005	003	000	000	004	L00	R01	U14	+15	3
1745	202,0		00762	232	-0320	141	147	272	272	00	27	000	27	172	005	003	000	000	004	L00	R01	U14	+15	4
1745	202,0	0000	00750	232	-0324	141	144	272		00	27	000	27	172	007	007	005	000	004	L00	R01	U14	+15	4

GMT	TCEN	WPA	WTT	SLAT	SLON	-----S	W	U	I	I	S	P	S-----	--I	L	S--	T/MCS-	----V	D	R-----	----A	D	F----	
U MM	S	FT	WT	1	2	1	2	3	4	5	1	2	3	4	5	12345	MA	MA	FREQUF	--1---	---2---	--1---	---2---	
																			MHZ	-MHZ--	--MHZ-	-MHZ--	--MHZ-	
1236	336.7	0070	224	22	1	00	1	1	-22	-22	-02	-02	1	-02	-22	-02	-02	11111	-007	-007	126.57			1*
1244	337.7	0000	224	22	1	02	1	1	-20	-02	-02	-20	1	-02	-20	-02	-02	11111	-007	-000				2*
1246	338.7	0000	220	22	2	00	2	2	0	-02	-22	00	00	0	-02	-00	00	00000	007	000	113.50		8640.00	3*
1246	338.7	0000	280	22	2	02	2	2	0	-22	00	00	00	0	-02	-00	00	00000	007	000	113.50		8640.00	4

SM	TCN	-MRA-VI	-----J-----	-----I-----	-----J-----	-LAT--	-LONG--	DN	AA	GD
H	NN	5	-----K-----	-----L-----	-----M-----	-----N-----	-----O-----	NEG.	NEG.	GD
1246	1336.7	024	+021 +001 +001 +001	+001 +001 +001 +001	+000 +000 +000 +000	+000 +000 +000 +000	+000 +000 +000 +000	11	11	11
1246	1327.0	024	+001 +001 +001 +001	+001 +001 +001 +001	+000 +000 +000 +000	+000 +000 +000 +000	+000 +000 +000 +000	11	11	2*
1246	1328.0	024	+001 +001 +001 +001	+001 +001 +001 +001	+000 +000 +000 +000	+000 +000 +000 +000	+000 +000 +000 +000	11	11	3*
1246	1329.0	024	+001 +001 +001 +001	+001 +001 +001 +001	+000 +000 +000 +000	+000 +000 +000 +000	+000 +000 +000 +000	11	11	4

-179.65 -179.65

GMT	TGMN	-BRA-	MET		M1		M2		M3		M4		M5	
			1	2	1	2	1	2	1	2	1	2		
M NR	S	CT	KT	°	°	°	°	°	°	°	°	°	°	°
1746	335.7	0000	774	254	256	-117	0000	256	256			000	000	
1046	327.0		074					256	256	256		000	000	14967 14847
1046	239.0		200	107	006	0025	0125	006	007			635	633	
1746	339.7		216					007	006	001		630	628	01277 01202

ST	REVER	FS	FC	PR	AI	FE	APU	X	AA
11	22			FC			APU	X	NS
12	UD	UD	12	12	12	12			1P
11	11	11	11	11	11	11	11	11	1 11 1*
11	11	11	11	11	11	11	11	11	111 1 11 2*
00	00	00	00	00	11	00	00	100	0 01 3*
00	00	00	00	00	11	00	00	000	0 01 4

0106

ACCORDING TO THE DATA FROM 174000-201 400007 05V LE 27/06/98

PAGE 9

GMT	200N	40R	001-	50A	40	0000	12	0	040	5/0	2	-DIRECTION-	-INCIDENCE-	SITE	DATA	---LAT---	---LONG---	F	
4 MN	0	0	0	00	14	0400	12	1	000	000	0	---D E G---	---[E]---			-D- MN S-	-D- MN S-D	/	
1744	000.0		11		11			1			1	000.2	000.2	000.2	000.2	4005	4005		1
1746	000.0		11				11	1			1	000.2	000.2	000.2	000.2				2
1748	000.0	1		11				0			0	000.4	000.4	001.1	001.0	4005	-00 52 31		3
1750	000.0	10				1	11				0	000.4	000.4	001.0	001.1		-179 38 43		4

DIRECTION DES OPERATIONS AERIENNES

Commandement

N. REF. DO. ND 50 420/JG.JSJ

Roissy, le 19 octobre 1987

DESTINATAIRE DO.VB - DO.VH - DO.VA - DO.VN - DO.VS - CEP.PN - CAR.GN

PLATAIRES DG.DT - DG.GN - DT.TI - DJ.NR - DO.NY

SCOPE : Tourist or demonstration flights (Ref. DO. ND 50 420)

The study of several low altitude flight cases by the Flight Analysis Commission leads us to remind you that all flights, or parts of flights, made for touristic or demonstration reasons, must be covered by the following :

- 1) an accurate definition, by the Flight Division concerned, of the performance conditions (distance, altitude, configuration, etc.) and the corresponding task sharing in accordance with sought objective,
- 2) written authorization from DO.ND with information to DO.NY.
- 3) meticulous preparation on ground and a complete briefing of the crew before the concerned flight phase is undertaken.

The general rules to be observed are :

- . minimum manoeuvring height : 600 ft radio altimeter,
- . minimum flyover height above runway of 100 ft in landing configuration and 300 ft in clean configuration.

Other more restrictive rules taking the conditions into account (weather, type of aircraft, environment, contour, air traffic, etc.) may be retained.

If any of these rules is not observed, the case shall be presented to the Flight Analysis Commission.

This, of course, also applies to all Systematic Flight Analysis anomalies in the normal sense of the term (excessive bank or vertical speed, GPWS, exceeding limitations (VFE, EGT, etc.)).

These flights, important for our public image, must be very carefully prepared and performed and the rules given above are a contribution towards this.

I am convinced that you will do all you can to observe them.

H. Petit

APPENDIX 10

Comparison between the performance recorded on A 320 No. 3 (flight No. 260) and on A 320 F-GFKC

The following sheet compares the performances measured on the A 320 F-GFKC in the last flight phase of the accident and on the A 320 No. 3 during a test performed in same configuration as the F-GFKC in this flight phase.

The comparison concerns the total height versus time variations which are representative of the aircraft performance report : the total height (H) is the sum of the real height (Z) and the $V^2/2g$ parameters (the square of the speed divided by twice the acceleration due to gravity). The total energy of the aircraft (E) at a given time is the sum of its potential energy (mgZ) and its kinetic energy ($1/2 mV^2$) ; the performance report can be reproduced by the variation of the total height which is proportional to E ($E = mgH$).

The flight phase of the accident taken into account in this comparison is :

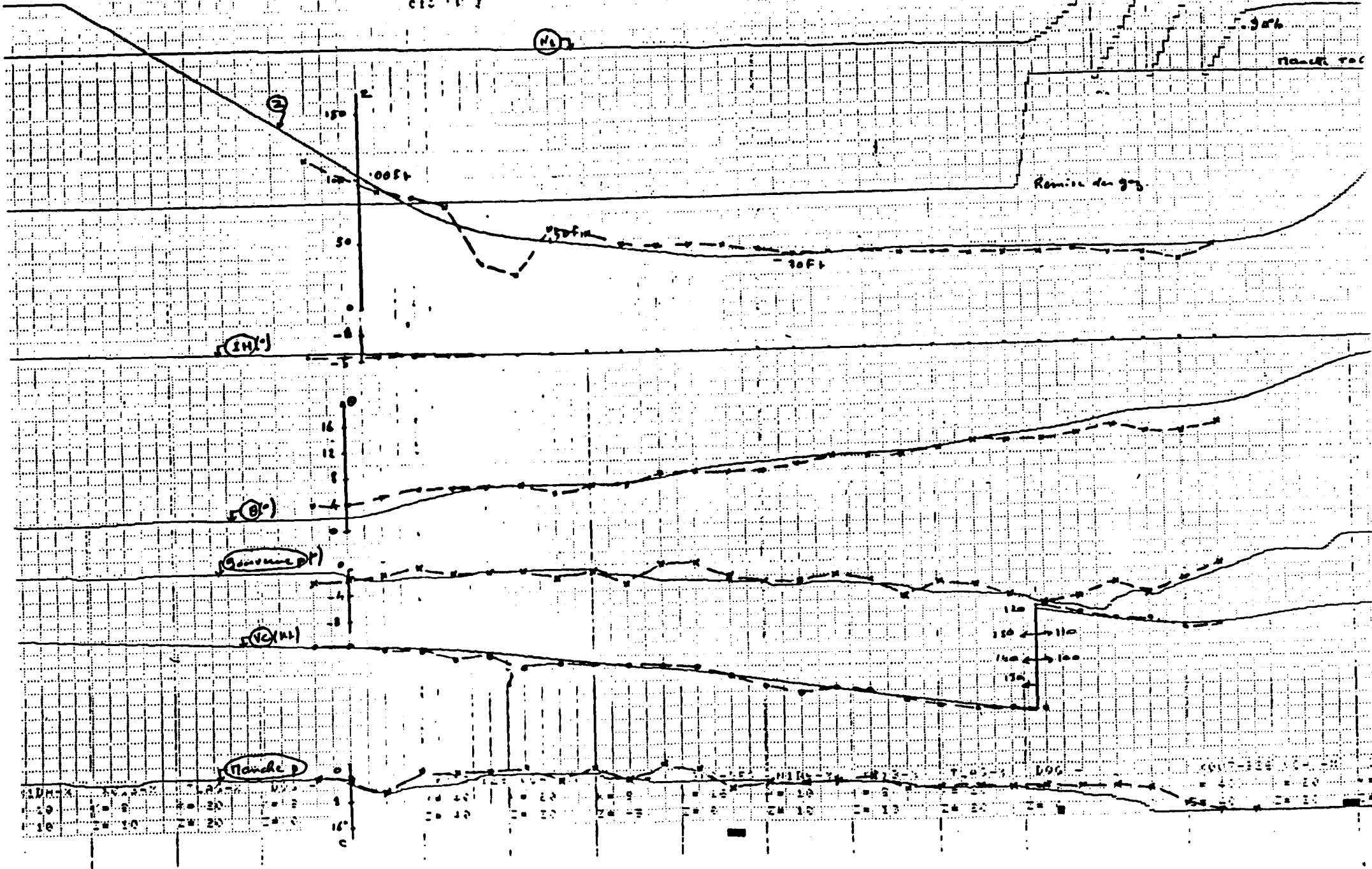
- for the F-GFKC, the final flight phase (descent then decelerating level flight between the 200 feet at 80 m/s and 30 feet at 63 m/s).
- for the A 320 No. 3, a descent decelerating between 2595 feet at 76 m/s and 2350 feet at 61 m/s.

The total heights variations (total gradient) during the same time interval are practically identical in both cases.

(as normal)

10

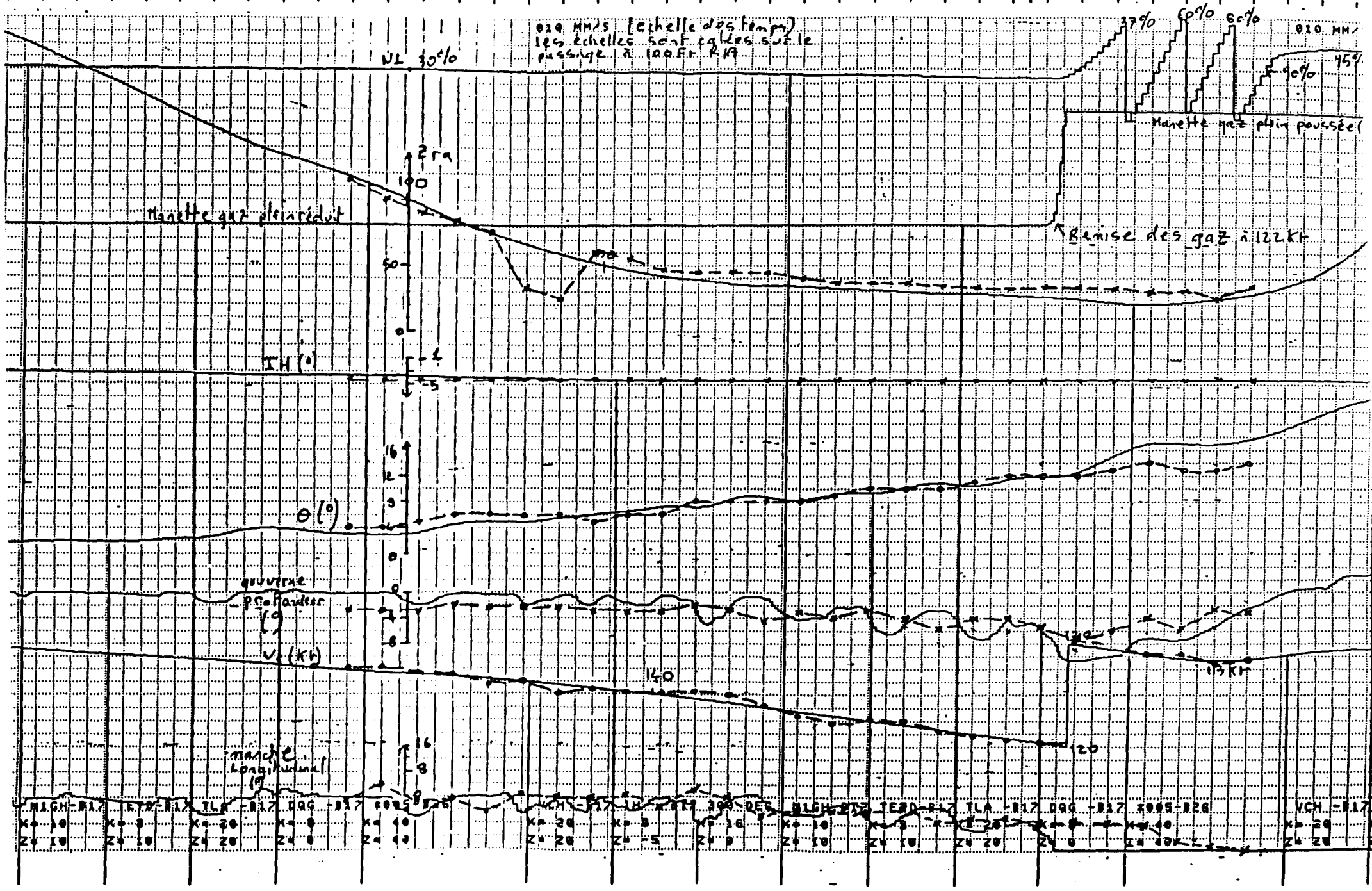
C10 1 1 2



2011 21/01/1953 retour de test MABUSHEIM U1: C. Bechet

010 MM/S (Echelle des temps)
les échelles sont calées sur le
passage à 100 Fr. R17

NL 30%



Manette gaz plein réduit

Manette gaz plein poussée

Remise des gaz à 122 Kr

IH(°)

O(°)

gouverne P. So. Harder (°)

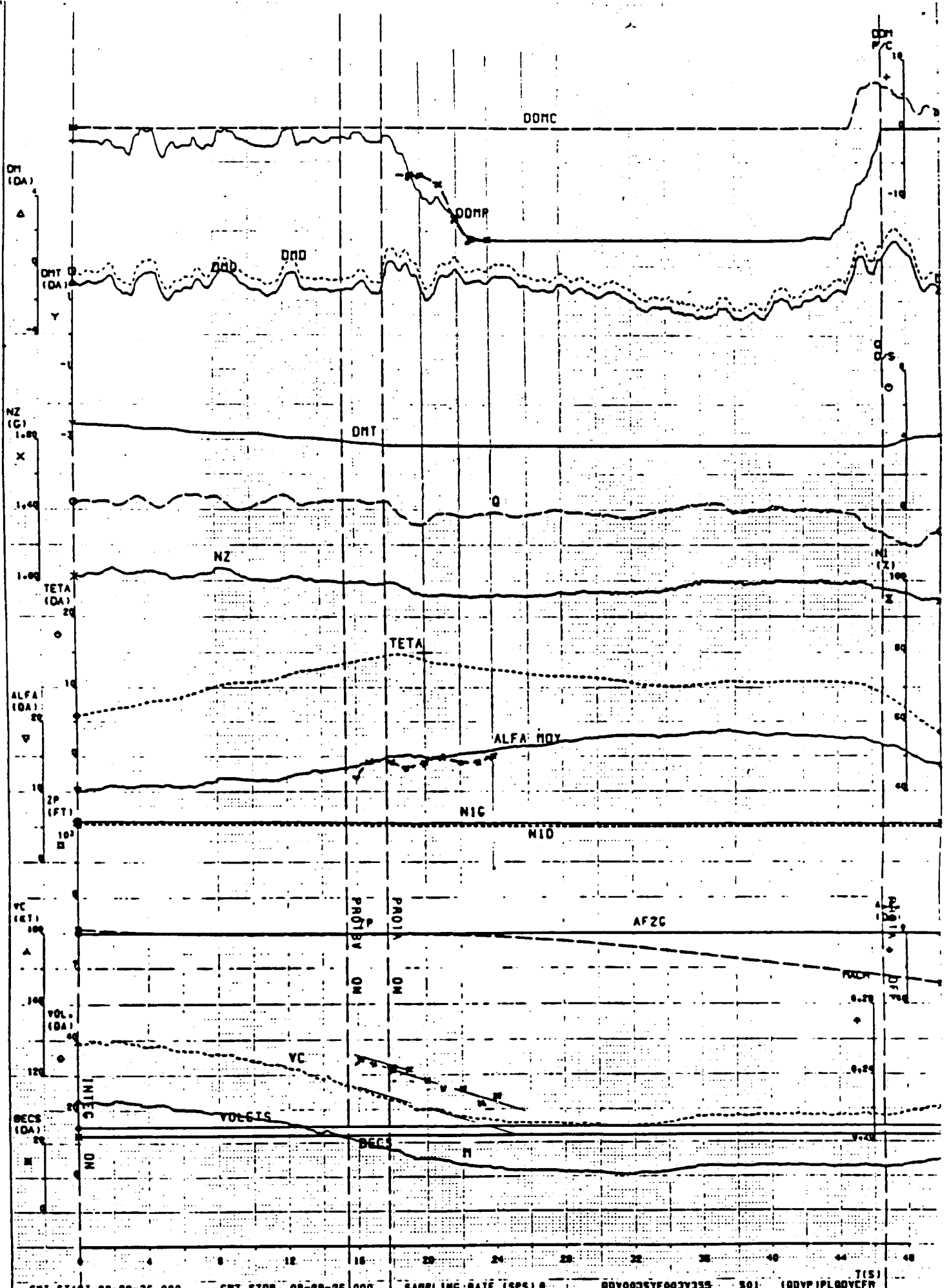
Vc (Kr)

manche longitudinal (°)

HIGH-R17 F.D.-R17 TL-R17 DQC-R17 FOS-R17 VCH-R17 HIGH-R17 F.D.-R17 TL-R17 DQC-R17 FOS-R17 VCH-R17

X-10 X-3 X-20 X-8 X-10 X-30 X-5 X-16 X-10 X-3 X-20 X-8 X-40 X-20

Z-10 Z-18 Z-20 Z-8 Z-10 Z-28 Z-5 Z-9 Z-10 Z-18 Z-20 Z-8 Z-40 Z-28



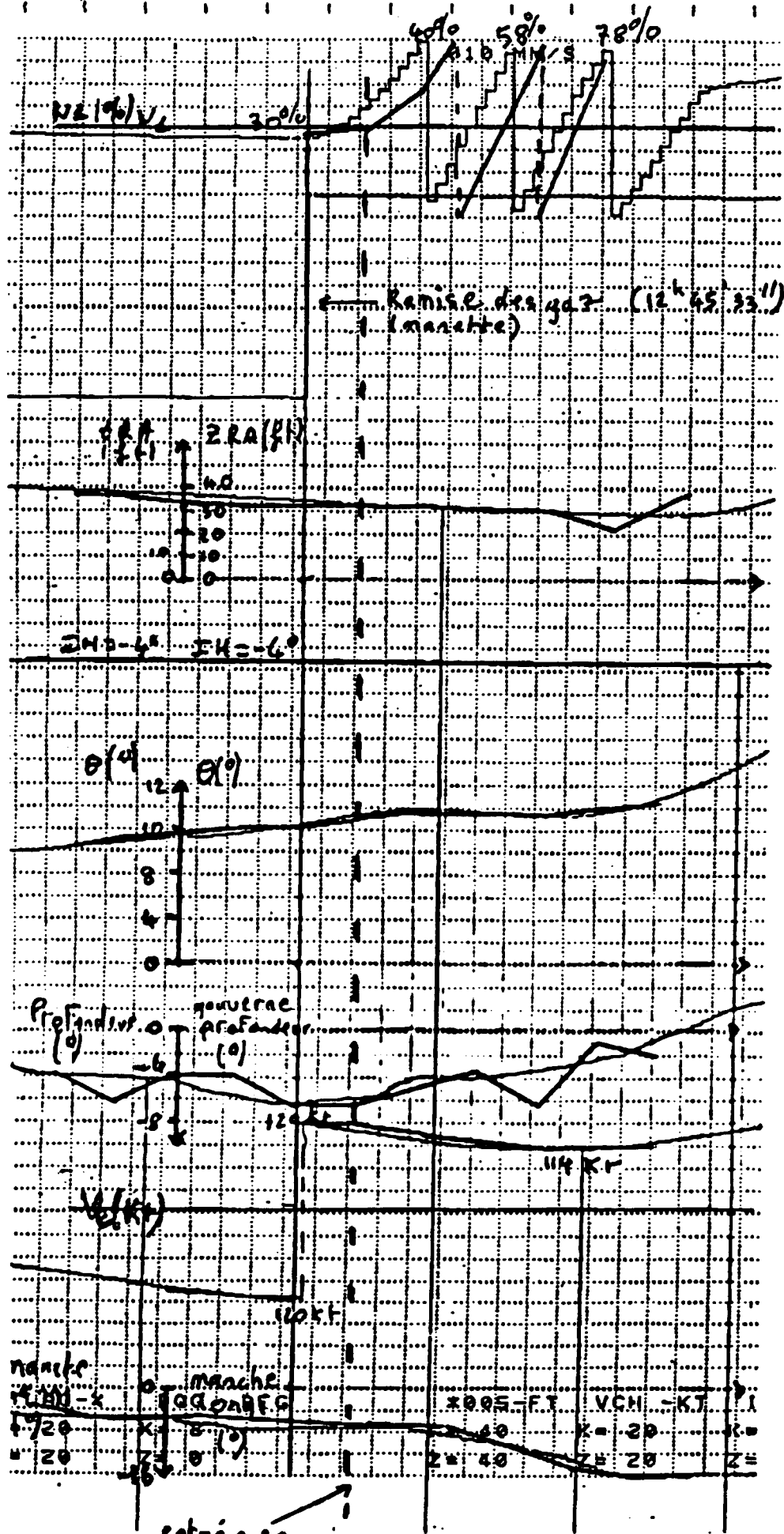
GRT START 00-20-36.000 GRT STOP 00-29-26.000 SAMPLING RATE (SPS) 8 00V0035YF003V335 501 (00VP1PL00VCFR)

FLIGHT V355		LON = 001.		IX = 1190. RZ.T		AEROSPATIALE FLIGHT TESTS	
ZP = 7556. FT VC = 130KT MACH = 0.225		NLON = 0.		IY = 2350. RZ.T			
MACH = 0.225		MYD = 123.		IZ = 3415. RZ.T		AIRCRAFT FOOD	
MACH = 0.225		IXZ = 140. RZ.T		FIGURE 3			

MACH = 0.225 BEC = 22. VOLET = 15. TRAIN = 0.25

Temps (s)

- Remise des gaz
- entrée en protection d'incidence

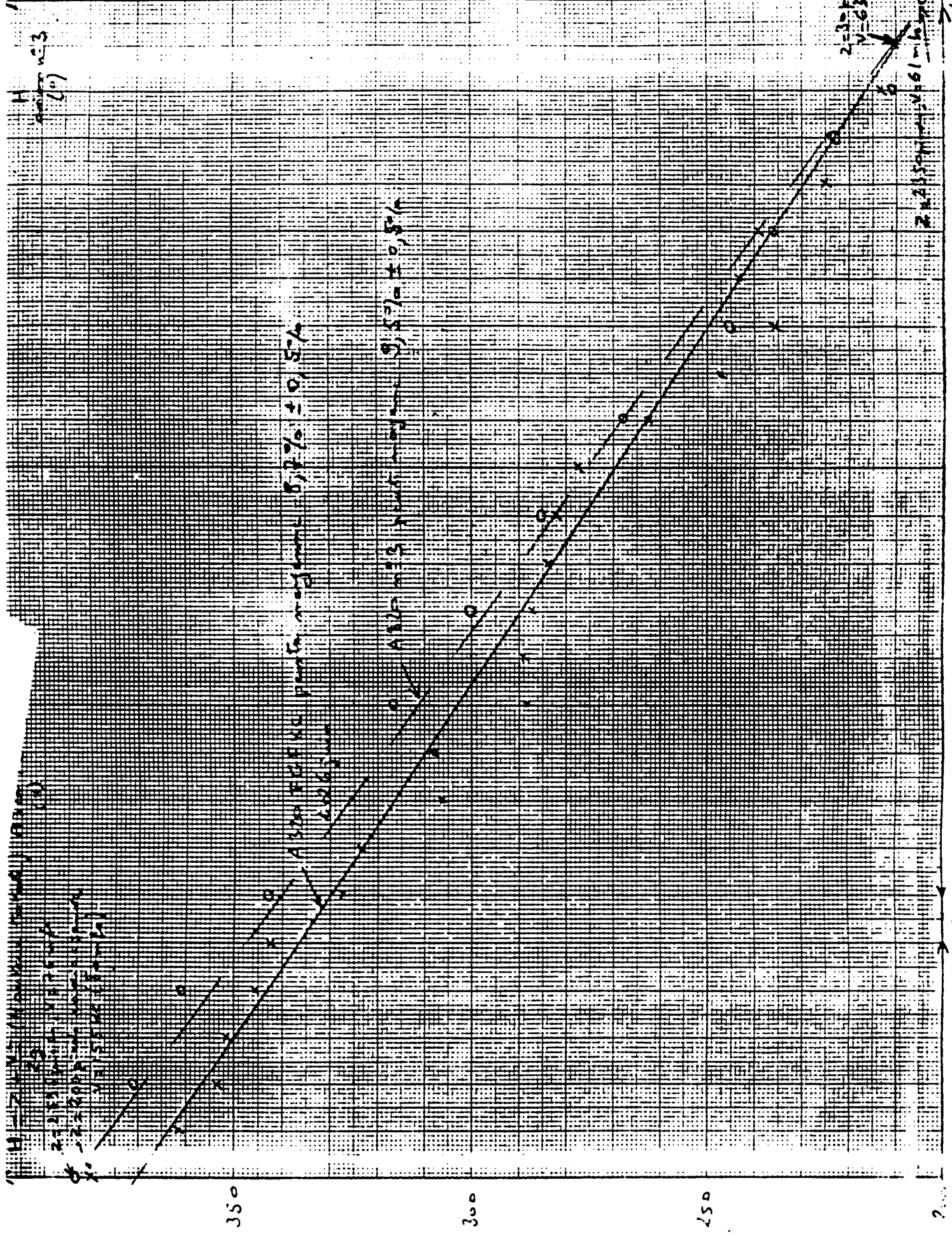


Remise des gaz (12h 45' 33'')

Recapement des dernières secondes de l'accident de l' A320 F-GFKC à Habsheim le 26 juin 1988 (entre t = 12h 45' 31" et t = 12h 45' 39")

Simulateur Aérospatiale S2 le 19/5/89

entrée en protection d'incidence (12h 45' 36'')



H
 250
 300
 350

t
 200
 300
 400

2-20-2000
 V=63 m/h

ASPHÉRIKAL Prof. mesur. 0,87% ± 0,5%

ASPHÉRIKAL Prof. mesur. 0,57% ± 0,5%