The A320 Habsheim accident

An Airbus Industrie response to allegations made in television programmes and other media

March 1991

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Introduction

This document has been produced as a response to allegations (direct or implied), made by the French pilots' union SNPL (Syndicat National des Pilotes de Lignes) and various media, that the Airbus Industrie A320 aircraft was in some way a contributory cause of the accident which occured in June 1988 involving an Air France A320 at Habsheim in eastern France.

Much of the media coverage reflects the content of the French Pilots' Union document "L'AFFAIRE / THE CASE" which has been widely distributed to

a) other pilot unions
b) airlines, worldwide
c) members of the French parliament
d) the media, worldwide

Parts of the media, in preparing their commentaries, seem to have drawn their conclusions from unsubstantiated opinions before hearing all the facts ... and in some cases even when in possession of the facts they have chosen to disregard them.

Due to pending legal actions, this response can only deal with statements made in public.

The A320 accident at Habsheim was the subject of an investigation by an official commission of enquiry appointed by the Minister of Transport which was assisted by the French accident investigation authority (BEA - Bureau d'Enquêtes Accidents). The final report was published in the "Journal Officiel" (French Official Gazette) and is available to the public. Another appraisal was conducted by two aeronautical specialists designated by an examining magistrate appointed to determine whether those accused of being responsible for the accident should be prosecuted on

charges of manslaughter. These enquiries, which are the sole objective elements available on the accident, showed that the crash was due to the overflight being conducted with insufficient speed of the aircraft (**too slow**), at **too low** an altitude, with the engines at idle and the action to initiate the go-around manoeuvre being taken **too late**.

The official enquiry into the accident was conducted by a seven-person team under the chairmanship of a senior airline captain, himself a member of the SNPL and highly experienced in accident investigation.

The two enquiries made use of all the information available:
video coverage,
on-site photographs,
police statements,
witness' accounts,
aircraft and engine inspection reports,
the recordings of the pilots' conversations both on-board the aircraft (cockpit voice recorder - CVR) and with the two Air Traffic Controls concerned,
and aircraft data as recorded by the flight data recorder (DFDR).

These investigations have concluded that the aircraft, and its engines, systems and equipment were not to blame. These conclusions have been accepted by all the world's certification authorities, including the CAA in Britain and the FAA in the United States. Also, it is worth noting that the NTSB were invited by the French authorities to participate in the investigation, which they did.

Appended to the document "L'Affaire / The Case" is a report by Mr. R. A. Davis, an aircraft accident consultant. In his report Mr. Davis claims that the Final Report of the French Accident Investigation Commission contains several statements which, according to him, are not supported by the evidence and which, he also claims, are in direct conflict with evidence contained alsewhere in the Final Report. He also alleges that some of the statements made in the Final Report are "completely erroneous".

Airbus Industrie has been informed by the BEA that Mr Davis's report contains very many factual errors and wrong conclusions. The BEA is issuing a detailed analysis of the report.

Note: Extracts and quotes from the Final Report are taken from the English translation thereof. Words in squared brackets [ ] are added by Airbus Industrie to make certain references more easily understandable.

Executive summary

The accident sequence

The accident occurred during a charter flight whose purpose was

1) to display the (at that time very new) A320 at a local airshow

2) to offer a free flight to winners of a competition

3) to be the first flight for a number of fare paying passengers

In preparing for the flight it would appear, according to the airline declaration reproduced in the Final Report of the investigating commission, that **neither of the pilots had first-hand knowledge of the airfield over which the demonstration was to be performed, nor did the (grass) runway over which the demonstration flights were occurring correspond to that** (a hard runway at 40° to the grass runway) **for which the pre-flight planning had been made.** Indeed, **none of the runways at Habsheim airfield are suitable for A320 operations.**

During the taxi-out from the departure airport (Basle-Mulhouse) the pilot indicated his intentions concerning the flyovers. The first was to be at low speed taking the aircraft to and stabilising at its maximum angle of attack with, **on the captain's order, the co-pilot increasing engine thrust to maintain a stabilised altitude and then selecting go-around thrust.** The second was to be at high speed. After the demonstration flights a sightseeing pass was to be made around Mont Blanc (France's highest mountain peak).

Executive summary (continued)

The flight from the departure airport to Habsheim, a ground distance of 16 kilometers, commenced with a take-off to the south-south-east followed by a right turn of 180°, which was commenced within a few seconds of the wheels leaving the ground, then, after alignment, following the route of a trunk road until the airfield was sighted, descending to make the first overflight.

It appears from the recordings of the discussion in the cockpit that the Habsheim airfield location was confirmed by the pilots late. The approach was made at a relatively high rate of descent. Indeed, as the aircraft passed through the "planned" overflight altitude of 100 feet above ground level the rate of descent was still 600 feet per minute (10 feet per second). The aircraft continued to descend in a shallow right turn with the engines still at flight idle and the aircraft passed over a clump of trees prior to the runway with a clearance of about 30 feet. Line-up with the runway and wings level flight occurred after the trees, with the engines still at flight idle and at a height reducing to its minimum of around 30 feet above the ground.

The pilot applied go-around power himself without any verbal comment when passing the control tower and approximately 4.5 seconds before the aircraft entered the forest into which it crashed. Almost immediately he pulled the control stick back, partially at first, then fully but at a time when the aircraft was already almost at the maximum angle of attack allowed in this flight condition and consequently also close to the stall speed. **There was insufficient time for the engines to accelerate to full power (from idle) and for the aircraft to regain altitude to avoid the trees.**

The post-crash investigations showed that the engines accelerated normally and the flight-envelope protection system prevented the aircraft from stalling.

Executive summary (continued)

Subsequent to the accident, the captain, with the backing of his Pilots Union (the French SNPL), has made a number of claims concerning what occurred, or may have occurred, in the cockpit during the overflight. Further, the SNPL has produced a document, L'Affaire/The Case, in which other claims are made concerning the validity of the Flight Data recorder transcripts and even the validity of the basic A320 design certification testing.

The Airbus Industrie position remains that the Commission of Enquiry has issued their Final Report and that the Report states unequivocally that the aircraft including the engines did not contribute to the causes of the accident. Further, neither the French Certification Authority (DGAC) nor any other certification authority has issued any requirements to modify the aircraft, its systems or its operating procedures as a result of this accident.

Airbus Industrie has also fully co-operated with the judicial authorities in their investigations into the causes of the accident, both direct and contributory, and has provided answers and explanations to all the questions raised. These, and further questions asked of Airbus Industrie's production and flight test partner Aerospatiale, have indicated the considerable depth to which the Commission and the judicial experts have performed their investigations in the areas which are now being questioned in the media.

Airbus Industrie realises, however, that the media coverage given to the claims made by the pilot and the claims contained in the document "The Case" question the validity of the Commission of Enquiry's Report. As a result Airbus Industrie has taken the decision to file suit as an interested third party in the criminal investigation being conducted by the examining magistrate in order to gain access to all the documentation available.

Executive summary (continued)

All the items which are included in the SNPL document "The Case" and all the statements made by the pilot have been reviewed by Airbus Industrie and in no case do the allegations made impact the conclusions of the commission.

There is now clear evidence from this accident that although the aircraft was in a corner of the flight envelope which would not be entered in normal flight, **the flight protection system operated perfectly and prevented the aircraft from crashing nose first.**

There is also clear evidence that **if** such a **demonstration flight** is to be made it should be made in **appropriate circumstances**, with the **correct preparation** and by a **flight crew who have total awareness** of not only the handling characteristics of the aircraft, but also the external environment in which the flight is to be made.

Perhaps the role of the pilot in the accident was summed-up during an SNPL meeting with the press on 5th November 1990 when the statement was made by a member of the SNPL board: "il ne faut pas oublier que M. Asseline a fait une grosse bêtise" which can be translated as **"one must not forget that Mr Asseline has made a big mistake"**.

The accident, the findings, the recordings and the Airbus Industrie participation

Summary of the accident

The Synopsis of the Final Report says:

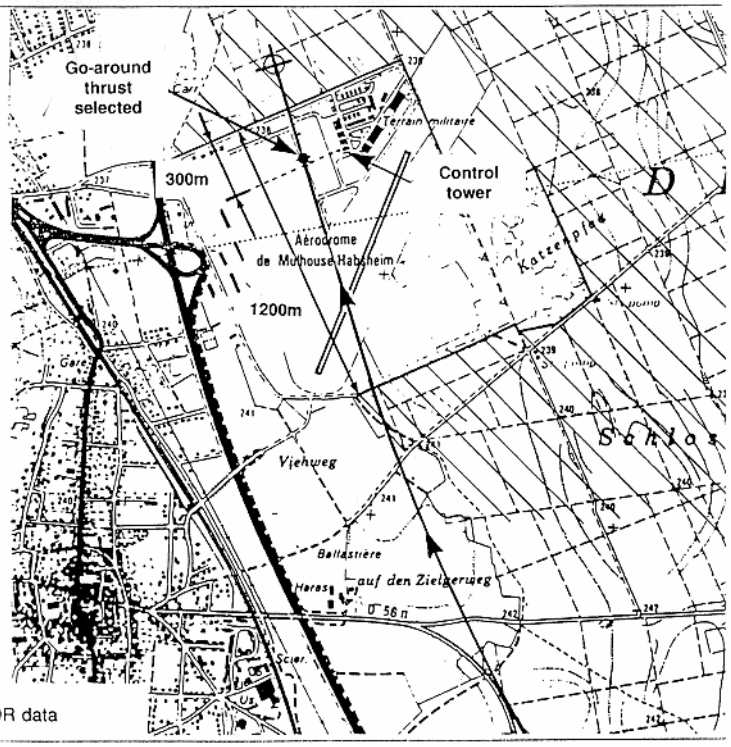
"As part of an airshow, the aircraft flew over runway 34 R at a height of approximately 30 feet, engines at idle, with an angle of attack increasing up to the maximum possible taking into account the deceleration rate of the aircraft. During the go-around, the aircraft touched the trees a short way beyond 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".

Key data concerning the accident

Date:	June 26th 1988
Airline:	Air France
Aircraft:	A320-100 serial number 009; registration F-GFKC
Engines:	CFM56-5-A1
Delivered:	June 24th 1988 (two days earlier)
Total flight hours:	22h 30min
Passengers:	130
Crew:	All Air France personnel 2 pilots - Captain Michel Asseline and Co-pilot Captain Pierre Mazieres 4 cabin attendants

This fly-by was made with one hundred and thirty passengers above a grass strip at a local flying club.

Flight path over Habsheim airfield



Reproduced by Airbus Industrie from DFDR data

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What did the pilot intend to do ?

The following conclusions are all part of the Final Report:

During taxiing at Basle-Mulhouse, before take-off, the captain specified his intentions for the overflights at Habsheim:

(1,2) overflight at 100 feet with the flaps in position 3 and landing gear extended,

(3) deceleration in level flight down to a minimum airspeed corresponding to the maximum angle of attack,

(4,5) after disengagement of automatic go-around protection at high angle of attack (alpha-floor), with assistance to control the aircraft required of the First Officer if holding the load on the stick became uncomfortable

(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.

Then a second flyover at high speed also at 100 feet.

Note: The above is extracted from page 50 of the Final Report (English translation)

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What actually happened ?

The following conclusions are all part of the Final Report:

- "Locating of the aerodrome was late".
- "Descent was started at 12h 43mn 44s (UTC) 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 above ground level was reached, the descent rate was still about 600 feet per minute"
- "The pilot levelled off at a height of about 30 feet, engines at flight idle, attitude increasing".
- "He did not have the time to stabilise the angle of attack at the maximum value that he had selected." (Note: the First Officer therefore did not need to move the thrust levers)
- "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 [air]speed 122 knots". (Note: The CVR record shows that this application of power was made by the Captain with no comment made to the First Officer.)

The above is extracted from page 59 of the Final Report (English translation). Notes are by Airbus Industrie.

The quality of the DFDR and CVR recordings

Quotes from the accident report:

- "The operation of the recorders was perfectly correct throughout the whole flight itself, i.e. until [the] first impact with the trees" (* see note below)
- "As concerns the CVR, the conversations and aural warnings were correctly recorded as well as 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"

... so are the claims of inconsistency, incomplete data and/or tampering justifiable? ...

Note:

* Elsewhere this is defined as "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."

Findings concerning the aircraft, weather, crew..

From the Final Report: (Text not in quotes is a précis of the Report)

- "The aircraft was in a flightworthy condition"
- The meteorological conditions were good and were not a contributing factor
- The crew was fully qualified and were instructor pilots with Air France
- ".. the performance of the flight controls of the aircraft was in compliance with the certification data .."
- "The response of the engines was normal and in compliance with the certification requirements"
- All the aircraft systems were in accordance with the specification

The aircraft and the engines were checked by the Investigation Commission and found to be operating correctly at the time of the accident and were not contributing factors

Airbus Industrie's participation in the investigations

Airbus Industrie's participation in the **Official Enquiry** was **specifically at the request of the Investigating Commission**. That the Investigating Commission should request the assistance of the aircraft manufacturer (i.e. Airbus Industrie) is standard practice (ref ICAO Annex 13) in any aircraft accident investigation.

Airbus Industrie was requested by the Commission to undertake the following:

- to make available certification data
- to make available technical specialists and to answer technical questions
- to run simulations of the aircraft trajectory and variations thereof
- to perform specific flights to reproduce key events that occurred during the fly-past. In this respect, the only low height flights that were made took place over the main runways at Toulouse-Blagnac airport.

In addition Aerospatiale, on behalf of the Flight Test division of Airbus Industrie, was mandated by the technical expert appointed by the Judicial Authorities to assist in the correlation of the CVR and DFDR recordings.

Statements concerning the Final Report

Criticisms of the Final Report

Statements have been made by various media in several countries and/or by individuals. The individuals include Mr Michel Asseline, the captain of the accident aircraft; Mr Christian Roger, Pilot with Air France and member of the SNPL; and Mr Ray Davis, a freelance aircraft accident consultant. These statements, and others, are dealt with individually in the following pages:

- The DFDR and CVR have been tampered with ....
- To get the results on the DFDR the laws of physics needed to be changed ....
- The barometric altimeter was reading incorrectly ....
- The flight controls did not follow the captain's orders ....
- The engines did not respond to the captain's demand for full power ....
- The tree height, at impact differs, indicating an engine failure ....

Has the DFDR been tampered with ?

The claims reviewed on the following pages are occasionally combined to create an accusation that the DFDR trace has been manipulated ...

- Taken in the context in which it has been inferred and with the knowledge that the final print-out has no gaps or areas of incoherent data, tampering with the DFDR must mean that some of the data has been changed.

The allegation that the DFDR had been tampered with was considered sufficiently serious to have caused the Government Minister responsible for the Investigating Authorities to have sued Mr Asseline and Mr Norbert Jacquet, also a former Air France pilot, for public defamation.

The court pronounced its decision on Monday 29th January 1991. Mr Asseline and Mr Jacquet were both found guilty of defamation, were fined, ordered to pay costs of the proceedings and are required to publish the judgement in five national French newspapers. Both defendants have appealed the decision.

The DFDR recording - a general comment

On the first transcript various data appear to be incoherent and two pieces of supposedly key data are incorrect. Certain commentators claim that "errors" in simple information such as this demonstrate that there could be errors elsewhere.

Further, some commentators are using an incorrect or over-simplified analysis of the parts of data from the transcripts to suggest further inconsistencies.

Finally, unjustified comments are being made concerning whether the DFDR trace shows the aircraft accelerating or decelerating in the seconds before impact.

The following pages refer to some of the key areas under question.

None of the above claims stands up to investigation. The DFDR trace is complete and shows no record of any aircraft or engine malfunction.

Note:The graphical representations of the DFDR data were prepared by Airbus Industrie from the data in the appendices of the Final Report. Recording times are adjusted to reflect the exact time at which each parameter is recorded. There remains a small potential error (up to 0.3 seconds) due to the variable delay between reading and recording a parameter.

The place and day of the accident ...

On the first transcript the location and date of the accident are incorrect.

- The DFDR recording is made in binary form in a sequence which is adapted to the aircraft concerned. The decoding is made using algorythms which are therefore also type specific. The Habsheim accident was the first occasion for which the CEV (Centre d'Essais en Vol at Brétigny sur Orge, near Paris) was required to decode an A320 DFDR tape and although the transcription algorythms had been written they had not been "calibrated". It is not surprising, therefore, that more than one run was required to transcribe accurately certain parameters.

- According to the first print-out the accident happened at a longitude and latitude corresponding to a location in Zambia and on the 31st May 1988. The data for the scene of the accident was not correctly decoded from the tape in the first reading. The third listing with the modified algorithm shows the correct location.

- The date of 31st May 1988 is quoted in the heading of the data print-out and was entered by the machine operator. Why the operator failed to enter the correct date is of no relevance to the recording on the DFDR.

The incorrect date and coordinates of the accident on the first transcript of the DFDR are totally irrelevant to the validity of the DFDR records

The completeness of the DFDR trace ...

Background:

On the first print-out a sequence of data appears to be (and is) incoherent. On later prints this sequence shows different data which together form a complete picture of the flight.

Comment:

- As is common with a first reading, **in this case made with a tape reading speed 8 times the recording speed** (the tape provides 25 hours of recorded data), a number of sets of incoherent data appeared on the print-out. In most cases the print-out shows an asterisk against these lines. Four lines of incoherent data are shown on the first print-out starting at a time 17 seconds before the aircraft entered the trees. It is clear from the data in the column refering to ground speed that there should have been more than four lines of data.

- According to the accident report **this event, during the first reading of the tape, was caused by a fold in the tape and/or dust particles present during reading and caused the tape reader head to lose contact with the tape.** The tape was thus cleaned and smoothed and the subsequent readings, made at a lower speed, allowed recovery of all the parameters.

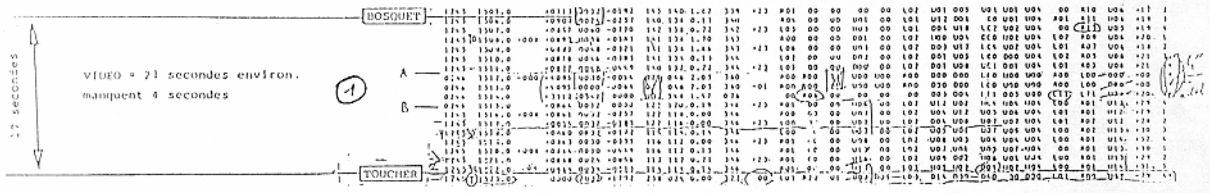
- When correctly read the tape provided 8 seconds of complete and totally coherent data. Comparison of the final DFDR print with the spectral analysis of the video recordings confirms the veracity of the final print-out and that the DFDR timing corresponds to the video recordings.

The DFDR provides a complete and fully coherent record of the entire flight through to a point 1 second <u>after</u> contact with the trees. The first reading of the tape failed to recover the available data for purely mechanical reasons. Subsequent readings provide all the data. *The first listing is, in effect, only a working copy.*

The completeness of the DFDR trace ...

Extract from the USPNT newsletter

The USPNT (Union Syndicale du Personnel Navigant et Technique) is a grouping of three trade unions, one of which is the SNPL. The "document" included in the newsletter is an extract from the first print-out of the DFDR, is marked confidential and was provided by the CEV to Air France. It includes the hand-written comments of the investigator and is dated 31/05/88 (see previous item).



Extract from Final Report showing the unread seconds

The accuracy of the DFDR trace ...

Some commentators have concluded that neither the DFDR speed nor IRS traces correctly represent the flight of the aircraft and suggest that, therefore, other data may be inaccurate.

- Any piece of equipment on the aircraft operates within a level of accuracy which is totally acceptable for its primary function, but may lead to minor variation when analysed out of context. This is not critical when looked at as groups of data but may lead to incorrect conclusions if selected values are taken.

- The IRS data recorded during the flight is neither absolute nor precise. The datum is entered either by the flight crew (with an accuracy of 1/600 of a degree i.e. 127 metres of latitude, 186 metres of longitude at Habsheim) or from the FMS database. The IRS measures relative movement including changes to the earth's gravitational force, i.e. to the earth's magnetic field, and therefore has an operating positional precision of around 2 nautical miles per hour of operation.

- The resolution of the recorded data and the frequency of its recording also varies. Examples are the ground speed which is recorded in 2 knot intervals, the Mach number which is recorded every 4 seconds and the IRS latitude and longitude output which is printed alternately every 2 seconds but read every 2.56 seconds. This precision and frequency are perfectly adequate for accident investigation requirements as this data can be cross-checked against other data and intermediate points estimated if required.

These basic facts are directly relevant when attempting to recreate the geographical location of the accident from the DFDR records

The tape has been cut ...

Alternatively, it is suggested that the DFDR tape was cut unnecessarily and that the DFDR could have been read intact.

- It is standard practice, following an accident, to open the inner box and to remove and open the tape container prior to reading to avoid accidental erasure or damage to the tape in the event that the internal mechanics of the recorder have been damaged in the accident. With this type of DFDR it is also necessary to cut the tape to allow it to be removed for reading.

- A video sequence shot on the premises of the LBA (German aircraft certification organisation) by the German TV station ZDF shows a DFDR apparently being fed into a reader without the DFDR having been opened. This is possible but the attention of the TV crew was drawn to the fact that, as stated above, this would not be done following an accident or at any time when the recorder could have been damaged. This warning was not referred to in any of the TV programmes. The video sequence actually shows a DFDR that is a) unsuitable for use in an A320 and b) incompatible with the DFDR reader shown!...

The DFDR tape handling procedure

Reproduced from the DFDR manufacturer's (Fairchild) manual

2. Removal of the DFR tape from the DFR

A. Remove dust cover from DFR

B. Remove stainless steel cover, thermal box and dust cover from DFR chassis.

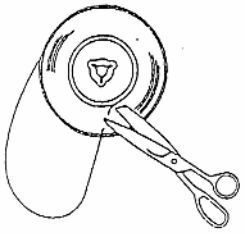
C. Remove reel cover which will now expose the tape. Loosen nut and remove tape guide retainer. Remove shoulder screw and VERY CAREFULLY remove the tape from the recorder.

3. Prepare tape for loading onto the HP transport.

A. Cut tape with scissors at the location where the tape feeds out of the center of the tape spool. (see diagram)

B. Tuck short section of tape coming out of the center of the spool back into the bundle.

C. Splice a six foot piece of CLEAR leader onto the end of the tape. Try not to get fingerprints on the tape.



The CVR recording

Transcripts of the recording are available in both the French original and the English translation of the accident Final Report. There are slight variances between this Final Report and the initial transcript of the text as published in the Preliminary Report. The following questions are raised concerning the transcript, and are used to try to cast doubt on the validity of the recordings.

Do the CVR and DFDR traces get out of step?

- Whilst the time is recorded continuously on the DFDR, and by the control tower(s) for any conversation involving them, there is no time recording on the CVR. However, the recorder does operate at a constant speed and therefore by calibrating the speed of the recorder during playing, to ensure that the pilots' comments to the control tower(s) occur at the same moment on both recordings, it is possible to allocate times to all the recordings on the CVR. There was, however, at the time of the accident, a small discrepancy (around 1 second) between the clocks in the control towers at Basle-Mulhouse airport and at Habsheim airfield.
- Mr. Davis has misunderstood the DFDR transcipt and claims that a comment made by the control tower and appearing on the CVR transcript is shown on the DFDR 4 seconds later. The DFDR only records communications made from the flight crew to ATC and not vice-versa. The indication shown on the DFDR that a communication is being made refers to the crew's response, which is also shown on the CVR transcript, and only one second different from the DFDR record. In view of the above, this one second discrepancy is to be expected.

According to the accident report:

"The consistency of the data obtained from the reading out of the CVR and the DFDR and certain outside media can be described as excellent".

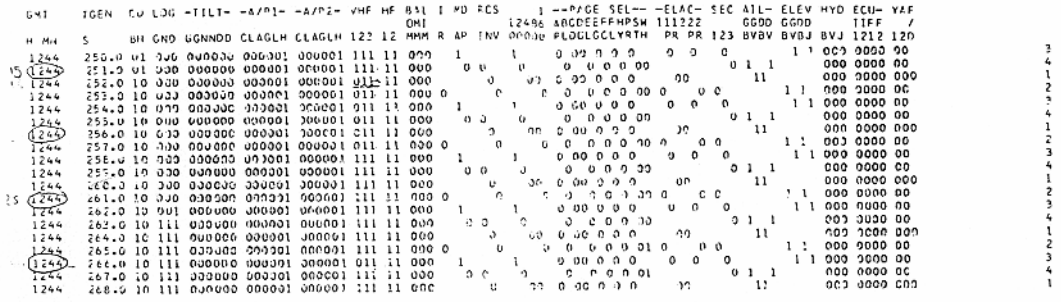
The CVR timing

The CVR record:

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	

The DFDR record of the above outgoing communications on VHF 1:

CVR time 12H 44' 17" equated to DFDR time TGEN 252
CVR time 12H 44' 31" equated to DFDR time TGEN 266
TGEN is the timing in seconds from the start of the DFDR reading made by the investigators.



The recorded positions of the aircraft

Comment:

Capt. Roger of Air France disputes the position of the aircraft at the point of impact. Capt. Roger claims that the geographical trace (i.e. the Inertial Reference System read-out) gives the impact at tree line whereas the speed trace gives the point of impact 300 meters prior to the tree line. Following this statement, which takes the latitudes and longitudes as "correct" values, Capt Roger states that "if the data is correct then the laws of physics need to be changed".

Response:

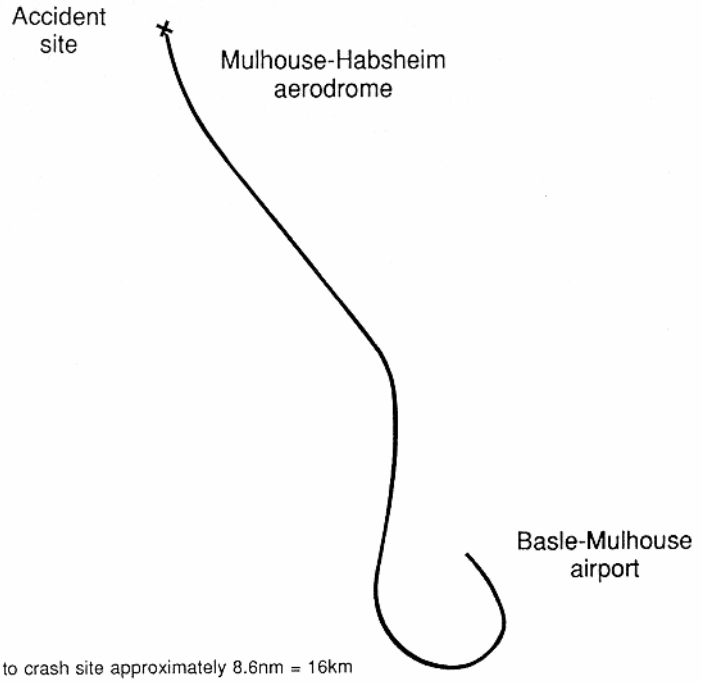
- The claims of Captain Roger are an excellent example of misuse of the DFDR data. The IRS provides data to the Flight Management and Guidance System which is the equipment which provides guidance to the pilot. The DFDR takes the raw data from the IRS every 4 seconds but the position computed by the IRS is only updated every 2.56 seconds.

- The IRS uses accelerations relative to the earth's surface (which is both rotating and curved) to calculate the position of the aircraft. As a result, the IRS has an operating precision, from a geographical point of view, of around 2 nautical miles per hour of operation with a further cyclic variation (the Schüler effect). These errors are far from constant and their rate of change fluctuates as a function of both time and the movement of the aircraft.The flight of the accident aircraft lasted around 5 minutes with several tight turns, accelerations and decelerations.

- The ground speed trace used for the calculations also has, as its source, data from the IRS. It is recorded and printed to the nearest 2 knots.

(continued)

The tortuous flight routeing



Not to scale.
Straight line distance from start of take-off to crash site approximately 8.6nm = 16km

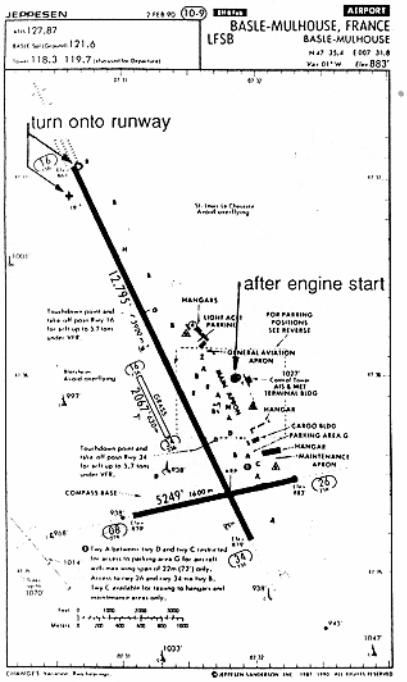
The aircraft position (continued)

*Taking all the factors into account it is, therefore, more **by chance** that the **position of the IRSs** at impact with the trees **appears to be "correct"**. The DFDR print-out shows that this was not always the case, even though the flight itself only lasted 5 minutes.*

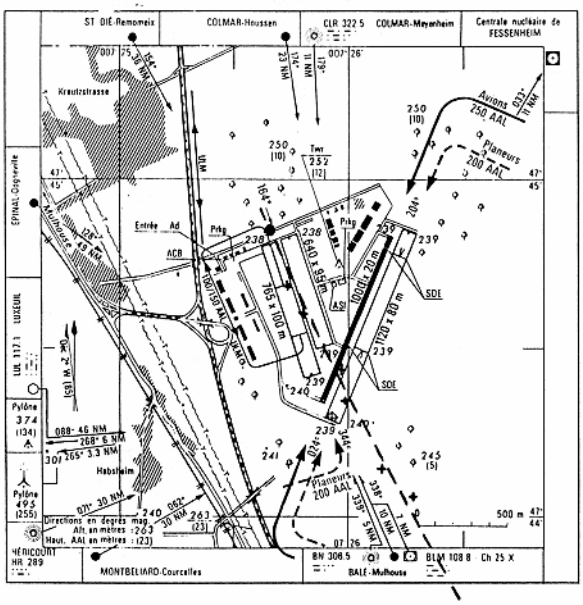
Calculating the distance flown from ground speeds would be extremely difficult for such a flight and once again, the claim shows that the person making the analysis has insufficient knowledge of the precision and source of the DFDR data and, in this case, the operation of an IRS.

The positions as recorded on the IRS on the ground

At Basle-Mulhouse prior to departure:



At the accident site at Habsheim:



o aircraft
+ IRS record

DFDR IRS "track"
(smoothed through points)

The barometric and radio altimeters

Comment:

Mr Asseline "I was too low because I suspect the barometric altimeter was at fault... the altimeter was showing 100 ft. although the aircraft was at 30 ft."

Response:

There is no record of any fault with either the barometric altimeter or the radio altimeter during the flight. There are clear indications of the barometric altitude readings in that during the descent the First Officer contacted Habsheim ATC, advised them of their intentions and was passed the Habsheim QFE (this is airfield pressure) of 984 hPa (hecto-Pascals = millibars). Subsequent investigation has shown that this value was correct to within 0.5 hPa, equivalent to 15 feet.

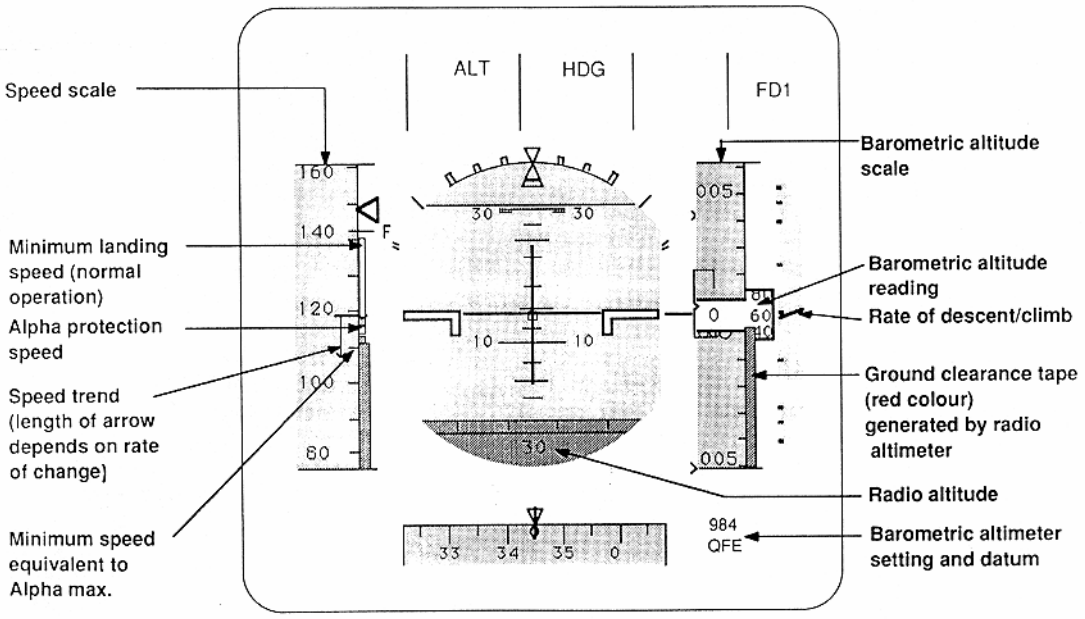
The First Officer was certainly aware of the radio altimeter call-outs since, when the aircraft passed through 100 feet and he began stating this verbally, he interrupted his sentence due to the radio altimeter announcement "100 feet". The First Officer also notified the Captain that they were reaching the planned height for level flight "O.K, you're at 100 feet there, ..." 20 seconds before the throttles were advanced. During those seconds further call-outs were made at 50 and 40 feet.

The Primary Flight Display (PFD) shows the radio altitude a) as a numeric value in the centre of the PFD and b) superimposed on the barometric altimeter for the last 570 feet as a red ribbon. When the aircraft has touched down the top of this ribbon is at the middle of the altitude window.

The barometric altimeter is an instrument whose intrinsic accuracy at low altitude is not adequate for low altitude operations. *It is standard airmanship to use the radio altimeter at low altitude (i.e. typically below 300 feet).* ***A low flyover based on the barometric altimeter cannot therefore be accurately achieved.***

The A320 Primary Flight Display

This example does not fully represent the PFD status during the overflight.



The barometric setting cross check

Comment:

Mr Asseline follows up his allegation concerning a barometric altimeter fault reference to an Operations Engineering Bulletin (OEB) on a "Baro setting cross check" (ref: OEB 06/2).

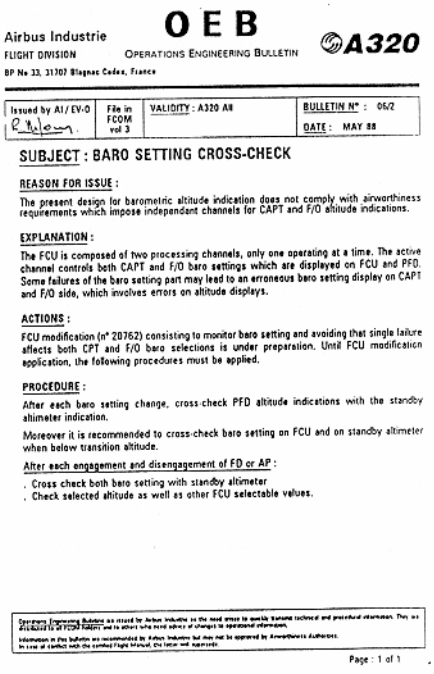
Response:

- This OEB concerns cross checking the Primary Flight Display (PFD) altitude indications with the stand-by altimeter indication after each baro setting change and after each engagement and disengagement of [an] FD (flight director) or AP (auto-pilot).
- The CVR record shows that on approaching Habsheim the barometric pressure was changed to a QFE of 984 hPa (hecto-Pascals=millibars). Both pilots confirmed this setting verbally.
- The OEB was sent to Air France on June 15th 1988 and acknowledged by Air France on June 17th 1988. It was Mr. Asseline's job as the Head of the A320 training subdivision and having participated in the acceptance flights for this aircraft a few days earlier to have been aware of this requirement.

Subsequent to the issue of the OEB it has been shown that the barometric altimeter indication on the Primary Flying Display can only change in flight due to a modification of the status of the FD, AP or Autothrust (A.Thr). No change occurred to FD, AP or A.Thr status after the QFE selection was made 25 seconds before impact.

The OEB concerning barometric altitude cross-check

Operations Engineering Bulletin 06/2



Airbus Industrie
FLIGHT DIVISION
BP No 33, 31707 Blagnac Cedex, France

O E B
OPERATIONS ENGINEERING BULLETIN

A320

Issued by AI/EV-D	File in FCOM vol 3	VALIDITY : A320 All	BULLETIN N° : 06/2
			DATE : MAY 88

SUBJECT : BARO SETTING CROSS-CHECK

REASON FOR ISSUE :

The present design for barometric altitude indication does not comply with airworthiness requirements which impose independant channels for CAPT and F/O altitude indications.

EXPLANATION :

The FCU is composed of two processing channels, only one operating at a time. The active channel controls both CAPT and F/O baro settings which are displayed on FCU and PFD. Some failures of the baro setting part may lead to an erroneous baro setting display on CAPT and F/O side, which involves errors on altitude displays.

ACTIONS :

FCU modification (n° 20762) consisting to monitor baro setting and avoiding that single failure affects both CPT and F/O baro selections is under preparation. Until FCU modification application, the following procedures must be applied.

PROCEDURE :

After each baro setting change, cross-check PFD altitude indications with the standby altimeter indication.

Moreover it is recommended to cross-check baro setting on FCU and on standby altimeter when below transition altitude.

After each engagement and disengagement of FD or AP :

. Cross check both baro setting with standby altimeter
. Check selected altitude as well as other FCU selectable values.

Page : 1 of 1

Note concerning pressure definitions referred to opposite:

QFE This is actual field pressure. On landing the altimeter will read zero.

Did the pilot attempt to apply thrust earlier?

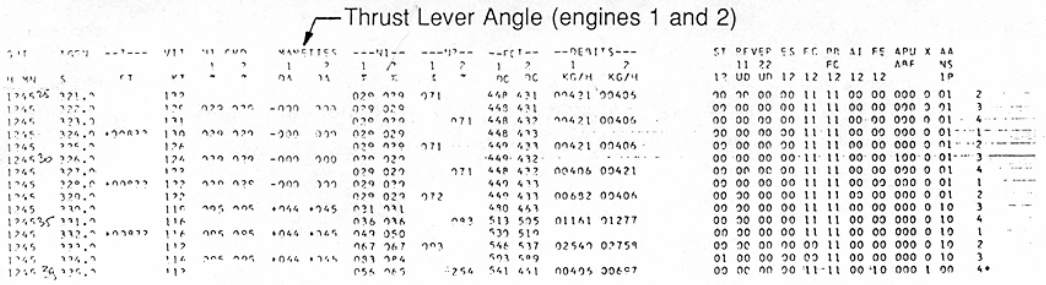
It has been suggested that during the seconds of the flight that were not correctly transcribed on the first DFDR print-out the pilot may have attempted to perform actions which could have prevented the accident.

- Although there are "unreadable" seconds in the first transcript, these seconds were correctly transcribed on subsequent print-outs and show no evidence to indicate that the pilot attempted to apply power (the thrust lever angle does not change during this time).
- There is no evidence from any other source that could indicate that the thrust levers had been moved or recycled during these critical seconds. Indeed, there is no sound of any thrust lever movement on the CVR other than at the time when the levers were pushed to the take-off/go-around thrust position.

There is no indication on any recording equipment to confirm the pilot's claim that he attempted to apply power earlier. Indeed, all the recordings demonstrate clearly that, ***over the airfield, he moved the thrust levers only once, from idle to go-around power, 4.5 seconds before tree contact.*** *i.e. as the aircraft passed the control tower.*

Did the pilot attempt to apply thrust earlier?

Extract from the DFDR trace



Extract from the CVR record

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)

Statements concerning the engines ... 1

Comment:

Mr Asseline claims that he "tried to get power sooner, but (I) had no power". Mr Asseline also states that he "recycled the throttles levers" (i.e. after starting to move them to a higher setting, retarded them back to idle then back up to the TOGA position) in order to "reset the computer".

Response:

- The DFDR trace of thrust lever angle (TLA) shows no indication of either "requesting power sooner" or "recycling the levers".
- In addition, the CVR recorded "clicks" when the throttles were moved to another detent,

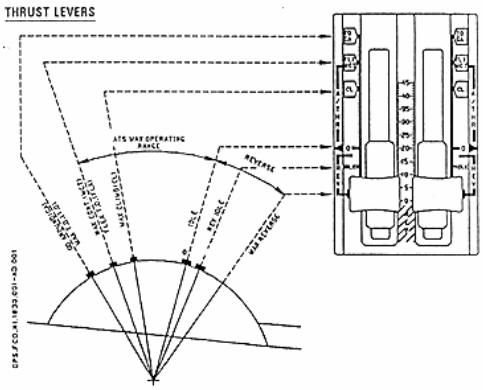
  Only one thrust lever movement is shown after flight idle was selected at the commencement of the descent, and concurrently with the clicks being heard, at 4.5 seconds before the aircraft enters the trees.

An Operations Engineering Bulletin (ref: 19/2), which concerns the "Lack of engine acceleration at low altitude", is shown in conjunction with the above remarks and is reviewed on the following pages.

The thrust lever movements recorded

Extract from the CVR record

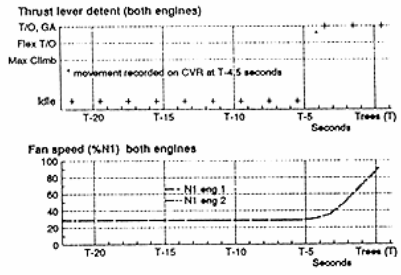
12 H 45'32"	F/O	Watch out for the pylons ahead eh see them ?		
12 H 45'33"	Capt	Yeah, Yeah don't worry		
12 H 45'34" 5/10				Clack ! Clack ! Clack ! (power lever detents)
12 H 45'35" 3/10				"Thirty" (radio altimeter)
12 H 45'36" 2/10				"Thirty" (radio altimeter)
12 H 45'37"	F/O	TOGA/SRS		
12 H 45'38" 3/10				"Thirty" (radio altimeter)
12 H 45'39"	F/O	Go around track		Increase in engine speed. Noise of impact in the trees.
12 H 45'39" 9/10	Capt	Sh.....t		
12 H 45'41" 5/10		END OF TAPE		



Extracts from the DFDR recordings

Tgen is time generated for this print of the DFDR tape

GMT	Tgen	Altitude feet	Air Speed	Thrust lever eng 1	Thrust lever eng 2	Engine N1 eng 1	Engine N1 eng 2
1245	332.0		136	333 035	-039	331	029 029
1245	333.0		131				029 029
1245	334.0	+00012	130	029 033	-039	330	029 029
1245	335.0		126				029 029
1245	336.0		126	029 029	-039	329	029 033
1245	337.0		125				029 033
1245	338.0	+00033	123	029 029	-039	330	029 033
1245	339.0		121				029 033
1245	330.0		116	035 035	+044	+355	031 031
1245	331.0		116				034 036
1245	332.0	+00332	114	035 035	+044	+355	042 050
1245	333.0		113				047 067
1245	334.0		114	035 035	+044	+355	053 084
1245	335.0		113				056 067



Statements concerning the engines ... 2

Background:

In the context of the alleged "lack of engine response" an Operations Engineering Bulletin (ref: 19/2) is referred to and the suggestion is made that it could have been relevant to the accident aircraft.

Comment:

- **The operating conditions at the time of the accident were radically different from the conditions stated in the OEB** (i.e. a combination of high aircraft speed, low altitude and engine acceleration initiated from N1 between 40% and 70%). At Habsheim the engines were at idle thrust (29% N1 RPM) until 4.5 seconds before impact and the aircraft at the lowest speed possible.

- Further, this OEB, covering a **potential** problem was applicable to the aircraft at that time. A modification to correct this problem was under study. **The aircraft (F-GFKC) was delivered to Air France two days earlier, was tested during the acceptance flights for this and shown not to be affected.**

Note: The OEB was sent to Air France at the same time as OEB 06/2 referred to earlier (June 15th 1988) and its receipt was acknowledged by Air France on June 17th 1988.

The OEB concerning engine response

Operations Engineering Bulletin 19/2

Airbus Industrie
FLIGHT DIVISION
BP No 33, 31707 Blagnac Cedex, France

OEB
OPERATIONS ENGINEERING BULLETIN

A320

Diffusion : 3 exemplaires à AFR le 15 juin 88

Issued by AI / EV-0	File in FCOM vol 3	VALIDITY : A320 CFM ONLY	BULLETIN N° : 19/1
			DATE : MAY 88

SUBJECT : ENGINE ACCELERATION DEFICIENCY AT LOW ALTITUDE.

REASONS FOR ISSUE :

It has been observed (recently), so far on test A/C only, that a VSV position control deficiency could prevent the engines from accelerating up to full power under certain flight conditions :
- Low altitude
- High A/C speed
- Engine acceleration initiated from N1 between 40 % and 70 %

Two production A/C (4 and 8) have been checked and no engine presented any sign of this problem.

EXPLANATION :

At this preliminary stage, only hypotheses can be formulated; in particular the reason why the test engines and production engines appear to behave differently has not been identified as yet.

The most likely reason for the problem is a lack of muscle pressure to control the VSV's to their intended position when aerodynamic loads are high.

Therefore the problem is unlikely to occur at low aircraft speed.

ACTIONS :

A full investigation has been launched to understand the problem and the recommendations will be reviewed as a function of the findings. As a precautionary measure the following procedure is to be applied, should the problem be encountered.

PROCEDURES :

If the « COMPRESSOR VANE FAULT » warning comes on ECAM at low altitude (below 10 000 ft), associated with a lack of N1 response (typical values for full throttle position : 100 % N2, 80 % N1), the fault can be cleared by decelerating the engine to idle and then performing a rapid acceleration from idle speed to full power.

Note : The ECAM procedure for compressor vane fault (Avoid rapid transients) should be disregarded in this case.

Operations Engineering Bulletins are issued by Airbus Industrie as the need arises to quickly transmit technical and procedural information. They are distributed to all FCOM Owners and to others who need advice of changes to operational information.
Information in this bulletin are recommended by Airbus Industrie but may not be approved by Airworthiness Authorities.
In case of conflict with the Certified Flight Manual, the latter will supersede.

Page : 1 of 1

The "boom, boom" sound on the CVR

Background:

In the CVR transcript contained in the Preliminary Report, at the time when the aircraft entered the trees, the text refers to "Increase in engine speed boom! boom!. This is followed by a blank line then "Noises of impact in the trees (two louder bangs)". In the transcript in the Final Report the words "boom, boom" are omitted.

Certain individuals, including Mr Asseline, claim that the "boom, boom" sounds could indicate an engine compressor stall. Are these claims valid?

Comment:

- The investigators have advised Airbus Industrie that the term "boom, boom" is their initial representation of the sound of the "noises of impact with the trees". Later versions of the text simply refer to "the noise of impact in the trees". The BEA (French Bureau d'Enquetes Accidents) advises that the initial text a) had a typing error - the blank line should have been before and not after the words "boom! boom!" and b) simply put words to the sounds heard and then interpreted their source.

- The spectral analysis of the sound-track of the video recordings shows no evidence of there being any "boom-type" sound other than that of the aircraft hitting the trees.

Note: it is extremely rare to have a compressor stall without causing the engine to spool-down. The DFDR trace and the spectral analysis of the CVR and video tapes show clearly that both engines were accelerating rapidly and normally as the aircraft touched the trees. Further, had an engine compressor stalled then eye-witnesses, passengers and the crew of the aircraft would have heard the sound clearly and it would have been recorded on the sound-track of the videos.

The "boom" sounds on the first CVR transcript

The transcript in the Preliminary Report:

F/O	TOGA/SRS/		"Thirty" ! (radio altimeter)
	..... Go around track !		Increase in engine speed
			Boom ! Boom !
Capt.	Sh..... !		Noises of impact in the trees (2 louder bangs).
	END OF TAPE		

The transcript in the Final Report:

12 H 45'38" 3/10				"Thirty" (radio altimeter)
12 H 45'39"	F/O	Go around track		Increase in engine speed. Noise of impact in the trees.
12 H 45'39" 9/10	Capt	Sh.....!		

Did both engines accelerate normally ...

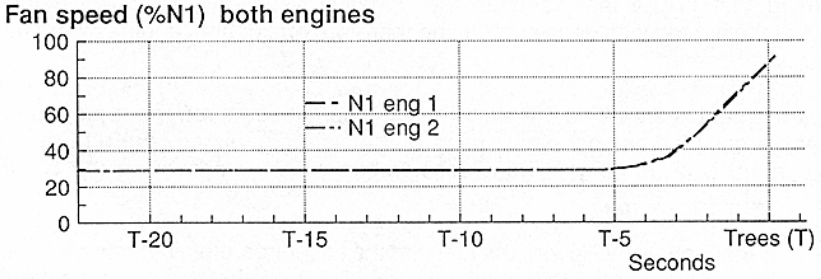
Having established that there is no evidence of either a compressor stall (see discussion concerning the CVR and the quoted "boom, boom" sounds) or that an engine failed to accelerate (previous page), it is appropriate to point out that a further piece of evidence leads to the conclusion that both engines operated in unison.

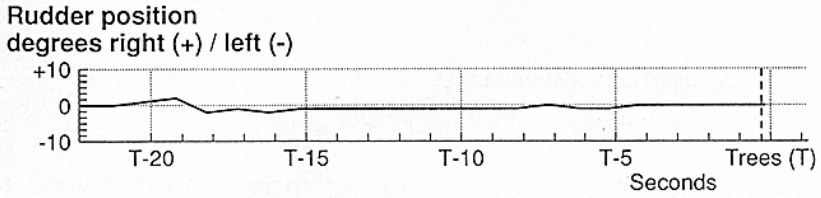
If either engine had failed to accelerate normally rudder deflection would have been required to maintain the flight path achieved

- At such a low speed the required rudder deflection would have been significant.
- There is no rudder deflection on the DFDR trace in the last seconds and nothing is visible on the video recordings.

In view of the trajectory followed by the aircraft, both engines must have accelerated in a similar way.

Did both engines accelerate normally ...





Did the aircraft decelerate prior to tree contact?

Mr. Davis was apparently not aware of the convention (which is apparently unique to France) that requires that the transcripts of forward accelerations are shown with a negative sign. They are therefore claiming that in the last seconds the negative acceleration shown in the transcript demonstrates that the aircraft was decelerating and therefore one or both engines were not providing sufficient thrust.

- The whole argument is sterile as the same convention is used throughout the transcript and is therefore easily checked against earlier parts of the flight e.g. during take-off where clearly the aircraft experienced a primarily forward acceleration which is shown on the DFDR trace as negative values!

Further, some "experts" apparently ignore the fact that the accelerometers measure total acceleration i.e. including gravity and that these are the values shown on the DFDR print-out. As the aircraft was at a high pitch angle during the fly-past the horizontal component of the gravitational force would be high. The longitudinal acceleration trace analysis allows us to demonstrate, without any ambiguity that

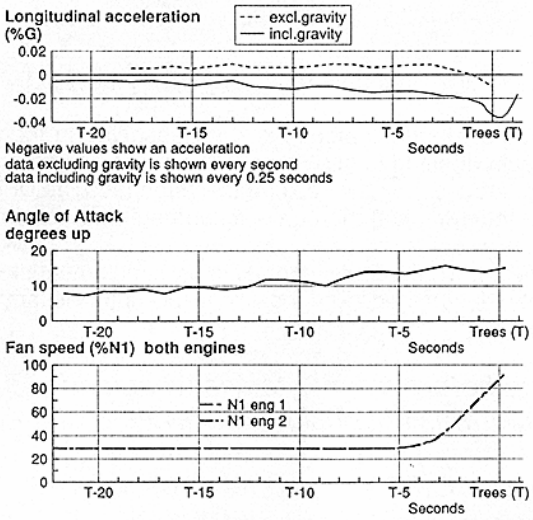
- the engines accelerated normally
- the aircraft longitudinal acceleration changes sign just before tree contact
- the aircraft entered the trees before the recorder stopped

The DFDR shows that the aircraft responded correctly throughout the flight

Did the aircraft decelerate prior to tree contact?

Extract from the DFDR transcript

The aircraft longitudinal acceleration (see page 55) includes the gravity component present due to the pitch attitude of the aircraft. Removing this gravity component shows that the aircraft was decelerating until the last few seconds when speed stabilised followed by an acceleration as the engine thrust increased but limited in time due to tree contact.



Statement concerning the impact with the trees

Background:

Mr Davis makes the claim that there is no evidence on the flight-data recorder of the impact of the aircraft with the trees. Further, Mr Davis claims that **"in his experience"** a recorder has never stopped instantaneously in a flat type of accident impact.

Response:

- There is clear evidence on the flight-data recorder of the impact of the aircraft with the trees.
- The flight recorders did not stop instantaneously at Habsheim. In the final report produced by the Commission of Inquiry it clearly states that "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 [after impact] then gave incoherent data for around two seconds".
- The exact cause as to why the recorders stopped almost simultaneously before the aircraft finally came to rest could not be determined. The most probable cause is that the power supply cables of the two recorders broke.

*The **important data is before impact** to see what leads up to the accident, not after impact. The aircraft was not designed to fly through trees, neither were the engines designed to ingest leaves and branches. Therefore it is not unreasonable to expect spurious data after impact.*

The impact with the trees

Extract from the final seconds of the DFDR transcript

Accelerations include the effect of gravity and are measured every 0.25 seconds except the vertical accelerations which are measured every 0.125 seconds.

GMT	Tgen	Altitude	Air Speed	Longitudinal acceleration				Lateral acceleration				Vertical acceleration							
1345	323.0		130	-310	-311	-311	-311	+001	+001	000	000	+102	+102	+102	+103	+103	+103	+103	+103
1345	323.5		131	-311	-312	-312	-312	000	+001	+001	+001	+103	+102	+103	+105	+105	+105	+105	+105
1345	324.0	+11111	130	-312	-312	-311	-311	+001	+001	+001	+001	+105	+105	+103	+103	+103	+100	+098	+099
1345	324.5		128	-310	-309	-309	-309	+001	+001	+001	000	+097	+095	+094	+094	+092	+092	+094	+094
1345	325.0		126	-310	-312	-312	-313	+001	+001	+001	+002	+095	+097	+097	+098	+098	+100	+100	+100
1345	325.5		123	-313	-314	-314	-315	+002	+002	+002	+001	+100	+100	+100	+100	+102	+102	+102	+102
1345	326.0	+11111	120	-315	-315	-315	-314	+001	000	-001	-001	+102	+102	+102	+100	+100	+100	+100	+100
1345	326.5		118	-314	-314	-314	-314	-001	000	000	+001	+094	+098	+098	+098	+099	+098	+098	+097
1345	327.0		116	-314	-314	-315	-316	+002	+002	+002	+002	+097	+097	+097	+097	+097	+097	+098	+098
1345	327.5		114	-316	-317	-319	-319	+002	+002	+001	+001	+098	+099	+099	+098	+098	+097	+097	+095
1345	328.0	+11111	114	-319	-319	-320	-320	+001	+001	+001	+002	+095	+094	+094	+094	+092	+092	+092	+092
1345	328.5		112	-322	-322	-325	-331	+001	+001	+001	+001	+092	+092	+092	+094	+094	+095	+097	+097
1345	329.0		114	-324	-324	-334	-337	000	000	000	+001	+099	+100	+100	+100	+100	+102	+102	+102
1345	329.5		117	-335	-347	-358	-190	002	+002	-222	+222	+102	+102	+102	+230	+223	+202	+200	+744

The last line shows rapid changes in accelerations measured as aircraft enters trees.

Does the tree cut height indicate an engine problem?

Background:

A few days after the accident the trees between the runway and the crash site were cut. Contrary to suggestions, this was done with the agreement, but not at the request, of the accident investigators to give access to the wreckage and permit its removal for analysis. At the insistance of the accident investigators the height at which the tops of certain trees had been severed by the aircraft were measured. The intention had been to measure those trees which were in the line of the engines. **The spacing between these two lines of trees was taken as 16 metres.**

The measurements show that the trees in the left line were severed at a higher level than those on the right. Certain people are claiming that this demonstrates that the left engine was providing less thrust than the right.

- ***The engines on the A320 are only 11.5 metres apart*** therefore the claims are invalid as the trees for which the heights were measured cannot have been under both engines.

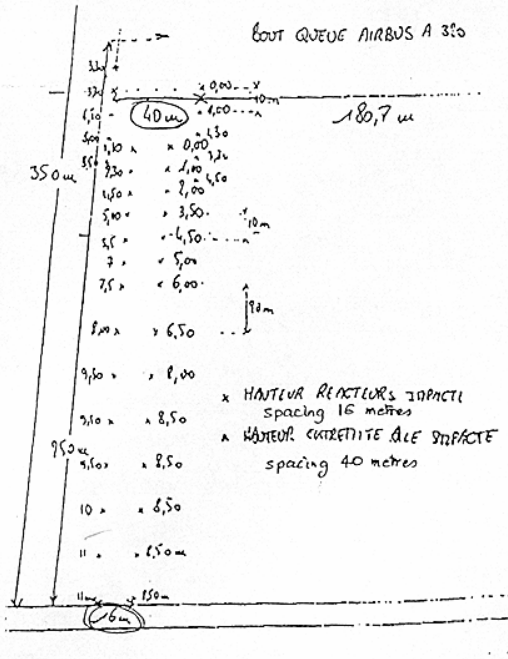
Also:

- Although the aircraft was at a low speed (for an aircraft in flight) **the cutting of the trees occurred not only due to the jet efflux** but also due to physical contact with the aircraft structure or engines. Indeed, the examination of the engines after the accident clearly shows a massive ingestion of leaves and branches into the core of the engine (i.e near to the centre).

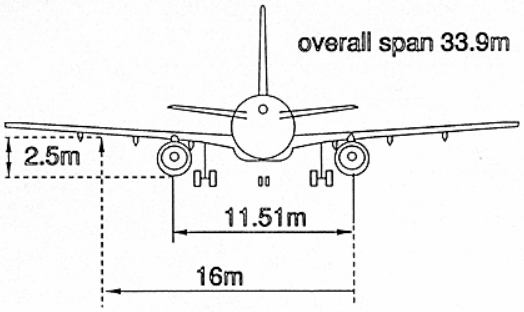
- The video clearly shows smoke plumes from both engines as the aircraft entered the trees and caused by ingestion of leaves. These plumes, contrary to the claim of one journalist, are of approximately the same size which suggests that similar thrust was being generated by both engines.

The tree height measurements vs the A320 ...

The tree cut heights



The A320 dimensions



Was this the real measurement?

The A320 with 15° pitch-up

316.0104/91 page 57

Was the accident avoidable?

On **passing the control tower**, given the aircraft's

configuration,

extremely low speed,

extremely low altitude,

that the engines were at idle

with go-around thrust not having been selected, at that time

the accident became unavoidable.

The reasons are:

- The total energy available to the aircraft at that time was insufficient to clear the trees.
- The angle of attack was already near its maximum
- The engines were at too low a speed to accelerate to an adequate level of thrust in the time available

In **summary:**

too low, too slow, too late.

The "blank" certification documents

Did "blank" certification documents exist?

It has been claimed that Airbus Industrie was in possession of certification documents from the French authorities which bore only the certification officer's signature and stamp ... and that consequently Airbus Industrie had the capability to produce aircraft documentation without the authorities being aware.

At no time has Airbus Industrie been in possession of any "blank" certification documents - either with or without the authorities' stamp and signature.

However, photocopies of a set of completed, stamped and signed documents for A310-324 MSN 452 (a Pan Am aircraft) were modified by a former member of the staff of Airbus Industrie, for use in a completely separate exercise (and a long time before the Habsheim accident), as an example of the paperwork provided as proof of airworthiness. The modifications involved "whiting out" all references to the aircraft concerned in the document **and also the document reference number (no. 14374 dated 30/9/87).** Thus, whilst the copy became a "blank, stamped and signed" example it remains a photocopy with no official reference number.

The French certification authorities later advised Airbus Industrie that such "examples" were inappropriate and action was taken immediately to change their presentation and the known recipients of the initial presentation material were advised accordingly.

The Lille and the Bangalore accidents

The A320 Lille accident

Comment:

The accident at Lille where an Air Inter A320 collided with a light aircraft on the runway has been cited as one in which the A320 design was a contributory cause. The facts were presented as a "fault of the A320" as the crew, so we are informed, "should have been able to have performed a go-around, thus preventing the collision". We are further informed that because the aircraft was in **land mode** the crew were unable to take control as "it was the computers that were flying the aircraft".

The facts:

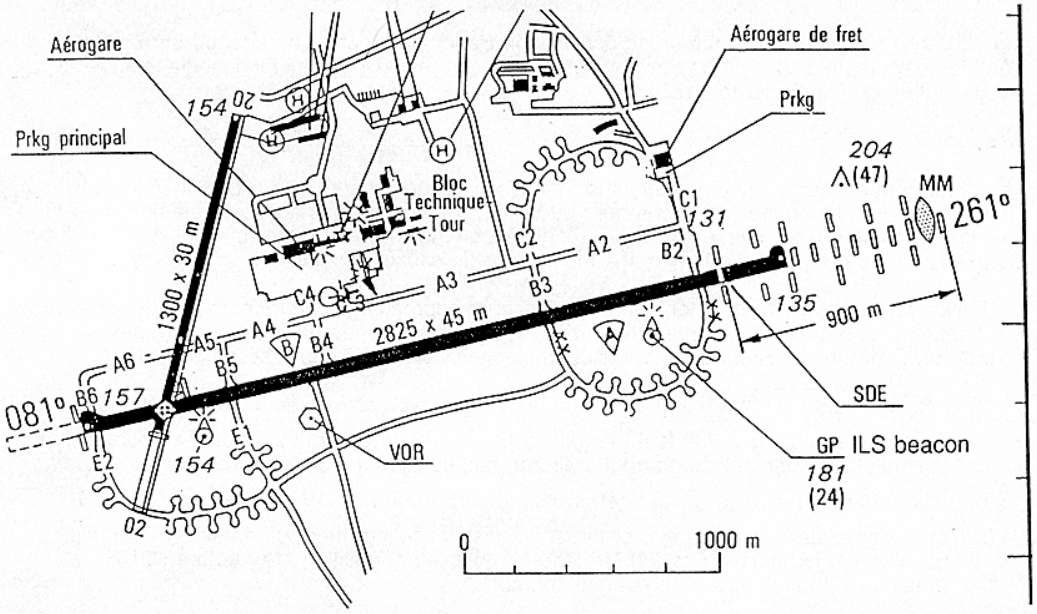
- The A320 was landing at Lille in thick fog - in fact a category III landing (i.e. no decision height and a runway visual range of 75 meters) - at the time of the accident. The light aircraft was cleared by air traffic control to the taxiway B3 holding point part way along the operating runway. **The pilot of the light aircraft, by mistake, taxied - without permission - onto the runway as the A320 landed.** The crew of the A320 saw the light aircraft at the last instant - just prior to collision - by which time the crew had already selected "reverse thrust".

- **At no time did the crew of the A320 contemplate trying to do a go-around.**

- The statement that the "computers" were flying the aircraft is true; **during any automatic approach and landing**, as on any other type of aircraft equipped with an automatic landing system, both the auto-pilots and auto-thrust are engaged. At any point during the approach and landing the crew can (if required) disengage the auto-land system and take control - as has always been the case **with any aircraft.**

The Air Inter crew and the A320 are not implicated in this incident

The site of the Lille incident



A320 made cat 3 landing on runway 26, touchdown close to taxiway B2 intersection
Light aircraft taxied off taxiway B3 onto runway 26

The Bangalore accident

Comment:

In February 1990 a second A320 crash occurred in Bangalore, India. The aircraft, on a scheduled flight from Bombay crashed short of the runway. It has been suggested in parts of the media that the aircraft fell, out of control, 600 feet prior to crashing.

Response:

The report of the Court of Inquiry appointed to investigate the cause of the accident was received by the Government of India on the 3rd December 1990. The Government has accepted the finding of the Court as regards the probable cause of the accident. According to the Ministry of Civil Aviation's report to Congress on the results of the Inquiry the most probable cause is expressed specifically as follows:

> "Failure of the pilots to monitor speed during final approach, probably because they diverted their attention to find out the reason for the aircraft going into idle/open descent mode rather than realising the gravity of the situation and responding immediately towards proper action."
>
> "This crash would not have happened if the pilots had taken one of the following actions:-
>
> (a) if the vertical speed of 700 feet [per minute] as asked for by Capt. Fernandez at about DFDR 294 seconds had been selected and the aircraft had continued in speed/vertical speed mode;
>
> (b) if both the flight directors had been switched off between DFDR 312 seconds and 317 seconds;
>
> (c) by taking over manual control of thrust i.e. disconnecting [the] auto-thrust system and manually pushing the thrust levers to TOGA (take-off go-around) position at or before DFDR 320 seconds (9 seconds to first impact on the golf course);

Note: DFDR xxx refers to the timing in seconds from the start of the DFDR transcript. The first ground contact occurred at DFDR 329 seconds.

(d) if the go-around altitude of 6000 feet had been selected on the FCU in accordance with the standard procedure at the time it was asked for by Capt. Fernandez."

"The most probable cause for the engagement of the idle/open descent mode during the short final approach is that instead of selecting the vertical speed of 700 feet per minute, the pilot (CM 2) had inadvertently selected an altitude of 700 feet by operating the altitude selection knob. As this altitude selected on the FCU was lower than the altitude of the aircraft at that time, the aircraft went into the idle/open descent mode."

"The court has ruled out any sabotage of structural, engine or any aircraft system's failure as the cause of the accident. All the systems of the aircraft, including the engines, were found to be performing normally. Specifically, the Court has observed as follows:-

"There was no defect reported, on the airframe, engines and their systems prior to the ill-fated flight nor any defect, abnormality or emergency reported during [the] flight by the pilots, till it crashed." (Finding No. 2)

"There was no apparent indication of any abnormality of [the] flying controls." (Finding No. 3)

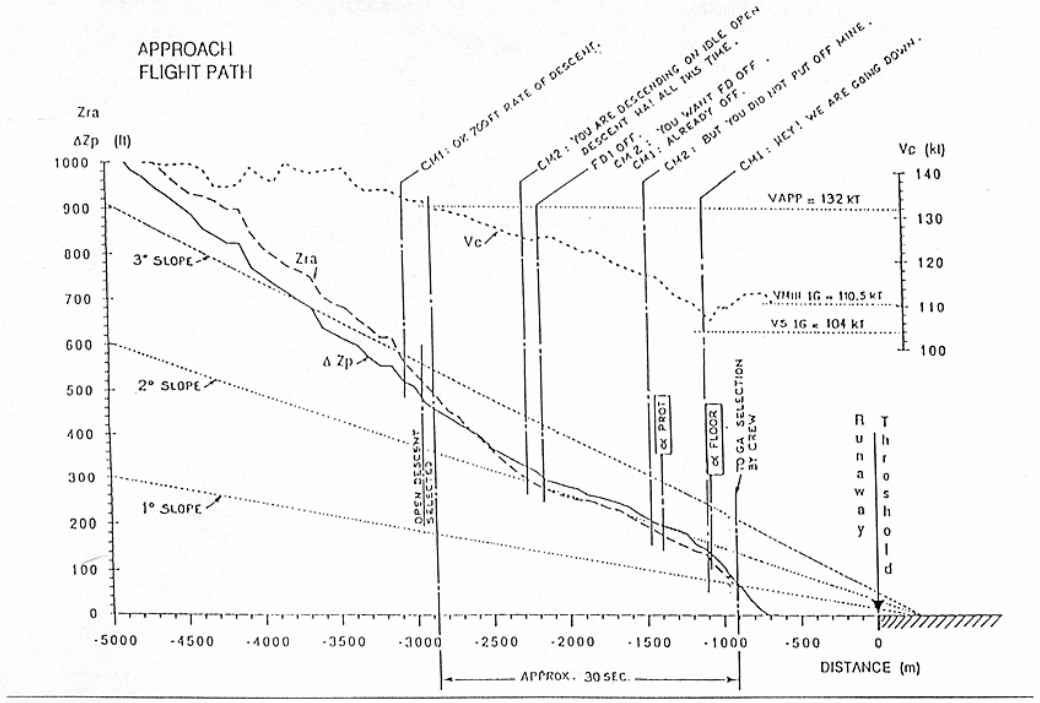
"All primary and secondary flight controls appeared to have operated normally." (Finding No. 80)

"The engines have operated normally throughout and have not contributed towards the cause of this accident." (Finding No. 82)

Airbus Industrie has requested a copy of the report and will advise A320 operators in due course of any significant conclusions to be drawn from the Inquiry.

The aircraft and engines appear to have operated normally and the flight-envelope protection system to have prevented the aircraft from a catastrophic stall. ***There is every reason to believe that, had there been no obstructions in the aircraft's path after touch-down most people would have survived.***

The flight profile during the last seconds



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Appendix
Extracts from the CVR transcription

The transcript of the CVR

An extract from the Final Report and retyped by Airbus Industrie for clarity

At Basle-Mulhouse during taxiing

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	- ACF296 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		

The transcript of the CVR

The last two minutes retyped by Airbus Industrie for clarity

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

The transcript of the CVR (continued)

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)
12 H 45'11"	F/O	P..... G.....!		allusion to airline flight safety officer
12 H 45'11" 4/10				"Two hundred" (radio altimeter)

The transcript of the CVR (continued)

12 H 45'12"	F/O	g..... is going to ...eh		(continuation of previous personal remark)
12 H 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		Increase in engine speed. Noise of impact in the trees.
12 H 45'39" 9/10	Capt	Sh.....!		
12 H 45'41" 5/10		END OF TAPE		