GRAND–DUCHY OF LUXEMBOURG

MINISTRY OF TRANSPORT

FINAL REPORT

ON THE ACCIDENT OF 6 NOVEMBRE 2002
AT LUXEMBOURG
TO THE LUXAIR FOKKER 27 MK050
REGISTERED LX – LGB

December 2003

FOREWORD

In accordance with Annex 13 to the Convention relative to the International Civil Aviation Organization and to the Luxembourg law dated 8 march 2002 on technical investigations in relation to accidents and severe incidents which happened in the domains of civil aviation, maritime transport and railways, it is not the purpose of the aircraft accident investigation to apportion blame or liability.

The sole objective of the investigation and its final report is the prevention of future accidents.

Consequently, the use of this report for purposes other than prevention may lead to wrong interpretations.

This report is a translation from the official report published in French.

CONTENTS

ABBREVIATIONS

AFM	Aircraft flight manual
AOM	All Operator Message / Aircraft Operating Manual
ATC	Air Traffic Control
BCMG	Becoming (TAF message)
BITE	Built in test equipment
BKN	Broken (TAF message)
BR	Mist (TAF message)
CRM	Crew resource management
CVR	Cockpit voice recorder
DFDR	Digital Flight Data Recorder
DME	Distance Measuring Equipment
EMI	Electromagnetic interference
FAF	Final Approach Fix
FDR	Flight Data Recorder
FG	Fog (METAR message)
FL	Flight level
FSK	Frequency Shift Keying
ft	Feet
GA	Go Around
GPWS	Ground Proximity Warning System
HDG	Heading
hPa	Hectopascal
IAF	Initial Approach Fix
IAS	Indicated Airspeed
ICAO	International Civil Aviation Organisation
IFR	Instrument Flight Rules
ILS	Instrument Landing System
kts	Knots
LH	Left Hand
LVO	Low visibility operations
ms	Millisecond
METAR	Meteorological aviation report
mph	Miles per hour
NDB	Non-Directional Radio Beacon
NM	Nautical Mile
NOSIG	No significant change (METAR message)

OVC	Overcast (METAR message)
PCU	Propeller Control Unit
PEC	Propeller Electronic Control
QFU	Runway magnetic direction
QNH	Pressure setting to indicate elevation above mean sea level
RVR	Runway visual range (Horizontal visibility on the runway)
RN	National road
RH	Right Hand
SB	Service Bulletin
SCT	Scattered (TAF message)
TAF	Terminal aerodrome forecast
TR	Aircraft type rating
UTC	Universal Time Coordinated
VHF	Very High Frequency
VOR	VHF Omnidirectional Radio Range

SYNOPSIS

Date of accident
Wednesday 6 November 2002 at 09 H 06[1]

Accident site
Niederanven, three point five kilometres to the east of threshold runway 24 of Luxembourg Airport

Type of flight
Public transport of passengers
Flight LG9642/LH2420 Berlin - Luxembourg

Aircraft
Fokker F27 Mk050 registered LX-LGB

Owner
LUXAIR

Operator
LUXAIR

Persons on board: 22
2 cockpit crew, 1 cabin crew, 19 passengers

Summary

During an ILS approach to runway 24, whilst established on the centreline, the aircraft disappears from the radar screens. It is located again at three point five kilometres to the east of threshold runway 24, seven hundred metres north of the centreline.

Persons on board	Persons			Aircraft	Load	Third parties
	Fatal	Injured	Not injured	Destroyed	Destroyed	-
Crew	2	1	-			
Passengers	18	1	-			

[1] Unless otherwise specified, times mentioned in this report are UTC times.

ORGANISATION OF THE INVESTIGATION

According to article 26 of the Chicago convention of the ICAO and its annex 13, the Grand-Duchy of Luxembourg, country of occurrence, started a technical investigation. An investigation commission was created by ministerial decree. The French bureau of investigation for the safety of civil aviation (BEA) was asked for assistance.

Investigators assisted by experts from the Dutch Type Certificate Holder Fokker Services B.V. and by technical and operational experts from Luxair have examined the site of the accident to secure material evidence. At the same time, the flight data recorders have been taken to the BEA for reading and analyses.

Representatives from the engine manufacturer Pratt & Whitney and from the propeller manufacturer Dowty joined the investigators and work continued on the first findings of the recorders and on the aircraft wreckage that had been transported into a hangar at Luxembourg airport.

The Netherlands participated in the investigation as State of manufacture of the aircraft. Germany, having suffered many victims, had delegated experts.

The technical investigation and the judicial investigation were closely coordinated during the first phase of the collection of technical information and of the examination of the components removed from the wreckage, with mutual respect to their individual procedures and objectives.

Investigations concerning the airframe, engines, propellers and different aircraft equipments were started immediately.

The first factual findings of the investigation were published in a preliminary report issued in January 2003.

After additional investigations and analysis by the experts of the BEA, all CVR and FDR read outs were validated and finalised.

A number of components and equipments, removed from the wreckage were sent to the manufacturers for examination and additional tests. These activities were done in the presence of the investigation team.

Additionally, the investigation team went to a Fokker 27 Mk050 flight simulator with the aim to reproduce the last minutes of the accident flight.

1. FACTUAL INFORMATION

1.1. HISTORY OF THE FLIGHT

The Fokker 27 Mk050 registered LX-LGB and operated by Luxair left Berlin on 6 November 2002 at 7 h 40 on flight LG 9642/LH 2420 with destination Luxembourg.

Cruising level was at FL 180. At 8 h 50, Frankfurt Control asked the crew to stop descent at FL 90, direct to Diekirch and at 8 h 52 the flight was transferred to Luxembourg Approach. They were instructed to enter the Diekirch hold at FL 90, to expect later on vectors for an ILS 24 and were given the latest RVR readings.

At 8 h 59, well before reaching the Diekirch hold, the aircraft was recleared to 3000ft QNH and to turn left heading one three zero. At this time the aircraft flew in the clear above a fog layer. RVR was two hundred seventy five meters. The crew evoked a go-around if the RVR was not three hundred meters whilst passing ELU (it's minima for a category II approach).

At 9 h 04 min 36s, the aircraft passed overhead ELU maintaining 3000ft QNH.

At 9 h 04 min 57 s, the ATC controller transmitted an RVR of three hundred meters. Power was further reduced, flaps 10 were selected and the landing gear was lowered.

Immediately after the landing gear was lowered, the pitch angle of the two propellers simultaneously reached a value that is lower than the minimum values for flight. This propeller pitch setting brought a rapid decrease of speed and altitude.

During the following seconds, the left engine stopped, then the right engine stopped. The flight data recorders, no longer powered, ceased functioning. At 9 h 05 min 42 s (radar time base), the aircraft disappeared from the radar screen. It was immediately found in a field seven hundred meters to the north of runway centreline 24 and three point five kilometres to the east of the threshold.

1.2. INJURIES TO PERSONS

Injuries	Crew	Passengers	Other persons
Fatal	2	18	-
Serious	1	1	-
Minor / None	-	-	-
Total	3	19	-

1.3. DAMAGE TO THE AIRCRAFT

The aircraft was destroyed.

1.4. OTHER DAMAGE

There was no damage to third parties.

1.5. PERSONNEL INFORMATION

1.5.1. Captain

Male, 26 years, airline transport pilot licence

Total flight hours:	4242
Hours on type:	2864
Last 3 days:	0
Last 28 days:	54
Last 30 days:	57
Day of the accident:	1 hour and 36 minutes before the last flight.

The captain resumed flying on 6 November 2002, after a rest period of 91 hours (standby).

Last checks:

Proficiency check:	1 June 2002(date provided by Luxair, documentation not on file)
Line check:	12 June 2002
Medical check:	19 June 2002, valid until 5 July 2003.

1.5.1.1. Licenses

- FAA CPL license N°2501396 issued 16.11.1994, Luxembourg validation N° 3488 dated 05.04.1995
- Swiss theoretical ATPL passed on 06.06.1995
- Swiss CPL license N° 36314 issued 07.11.1995 with Fokker 27 Mk050 co-pilot type rating, Luxembourg validation N° 3721 on 20.02.1996
- Swiss ATPL captain Fokker 27 Mk050 issued 16.03.1999

1.5.1.2 Qualifications

- TR captain Fokker 27 Mk050 valid until 14.12.2002
- IR/CATII captain Fokker 27 Mk050 valid until 14.12.2002

1.5.1.3 Aeronautical career

- Contract Luxair Commuter as of 1 April 1995 with total flying hours on glider, single and multi engine aircraft of about 236 hours.
- Type rating co-pilot Fokker 27 Mk050, July 1995
- Contract Luxair as of 10 February 1996
- Type rating co-pilot B737, July 1997
- Conversion and type rating to captain Fokker 27 Mk050 started beginning of 1999.

1.5.2. Co-pilot

Male, 32 years, airline transport pilot licence

Total flight hours:	1156
Hours on type:	443
Last 3 days:	0
Last 28 days:	50
Last 30 days:	54
Day of the accident:	1 hour and 36 minutes before the last flight.
Last flight before the accident:	1 November 2002

Last checks:

Proficiency check:	22 June 2002(date provided by Luxair, documentation not in file)
Line check:	13 June 2002
Medical check:	30 November 2001, valid until 14 January 2003

1.5.2.1 Licenses

- FAA CPL license N° 2511212 issued 28.04.1995
- Luxembourg PPL license N°865, issued 30.08.1996 with aerobatics and instrument flight qualifications.
- German ATPL license N° 11500 issued on 19.06.2000 with 700 flying hours. Luxembourg validation N° 4971 dated 12.12.2000.

1.5.2.2 Qualifications

- IR/CAT II valid until 14 January 2003

1.5.2.3 Aeronautical career

- Freelance pilot flying on Short Skyvan and Britten Islander with around 300 hours.
- ATPL training between 1998-2000
- Luxair recruitment process (interview on 10.07.2000, psychological test on 13.07.2000, flight test on 26.07.2000 and recommendation on 28.11.2000.)
- Contract Luxair dated 04.12.2000
- Fokker 27 Mk050 ground course completed December 2000
- Fokker 27 Mk050 co-pilot conversion and type rating completed Dec 2000/Jan 2001.
- Type rating F27 Mk050: June 2001

1.5.3. Cabin crew

Female:	32 years.
Entry date at Luxair:	16 February 1995.
Last checks:	18 May 2002.

1.5.4. Air traffic control

Approach control, taking over traffic from foreign centres for integration into the approach sequence, was performed in a dedicated radar room. Staff present at the moment of the accident was:

- One qualified radar controller working on the radar position
- One qualified radar controller working in the assistant/coordinator position

Aerodrome control, takes over from approach control. Staff present at the moment of the accident was:

- One qualified aerodrome controller working on the aerodrome position
- One qualified aerodrome controller working in the assistant/coordinator position
- One trainee with no duties assigned.

1.6. AIRCRAFT INFORMATIONS

1.6.1. Airframe

- Manufacturer: Fokker Aircraft BV (Netherlands)
- Type: F27 Mk050
- Serial N°: 20221
- Airworthiness certificate:
  - Delivered on 26 June 1991
  - Valid until 19 June 2003
- Flight hours up to 6 November 2002: 21 836
- Cycles up to 6 November 2002: 24 068

1.6.2. Engines

Manufacturer: Pratt & Whitney Canada

Engine	Type	Serial Number	Operating hours	Cycles
Left	PW 125B	124315	20 372	22 060
Right	PW 125B	125004	18 454	20 077

1.6.3. Propellers

Manufacturer: Dowty Propellers

Propeller	Type	Serial Number	Operating hours	Cycles
Left	R352/6-123-F/1	DRG8487/89	18 008	16 958
Right	R352/6-123-F/1	DRG11867/89	17 923	19 470

1.6.4. Mass and balance

The aircraft was within the approved weight and balance envelope.

1.6.5. Maintenance and airworthiness

The evening before the accident an « 230 flight hours inspection » was performed with a satisfying result. Upon completion of the inspection, the aircraft was released to service by the issuance of a Certificate of release to Service (N°3769).

The hold item list (HIL) mentioned an inoperative antiskid system on the right hand landing gear up to the 5 November 2002 (date of the inspection). This anomaly was first detected on 27 September 2002 and the RH antiskid harness had been replaced. On 24 October 2002, the same system was inoperative again. Despite changing the outboard wheel speed sensor, the system remained inoperative. The problem was resolved on 5 November 2002 by replacing the RH inboard wheel speed sensor. This was listed on the HIL N°00321 as item D, which was by that action cleared on 5 November 2002.

1.6.6. Aircraft type certification

The Fokker F27 Mk 050 is an aircraft derived from the F27. A lot of modifications were introduced, mainly very advanced cockpit equipment with monitors for flight data, different engines and propellers. The first flight of the prototype was on December 28, 1985.

The type certificate was issued on May 15th, 1987 by the Dutch authorities. The production ran from 1987 until May 1997. 208 aircraft were built including 2 prototypes.

The FAA Type Certificate was issued on 8 February 1989 and the aircraft is in service with 30 operators on all 5 continents.

1.7. METEOROLOGICAL INFORMATIONS

1.7.1. General situation

Luxembourg was under the influence of high pressures, with a low centred over Iceland and a low-pressure system moving slowly to the east.

This generated persistent fog, which only cleared during the early afternoon hours.

1.7.2. Situation at the aerodrome

Meteorological information recorded at the airport is integrated into the ATIS message. For this period of time, the meteorological values were as follows:

METAR from 7 h 50: 00000KT 0100 R24/250N FG OVC001 04/04 Q1024 NOSIG
METAR from 8 h 20: 00000KT 0100 R24/250N FG OVC001 04/04 Q1024 NOSIG
METAR from 8 h 50: 00000KT 0100 R24/250N FG OVC001 04/04 Q1023 NOSIG
METAR from 9 h 20: 00000KT 0100 R24/250N FG OVC001 04/04 Q1023 NOSIG

Recorded RVR values as shown in appendix 14 are minute averages. The RVR given by ATC is the actual measured value which is updated every 15 seconds.

The forecast established for this period was as follows:

TAF from 6 h 00: 060600 060716 18003KT 2000 BR BKN003 TEMPO 0710 0100 FG BKN001 BECMG 1113 18007KT 5000 NSW SCT015 BKN030 BECMG 1215 18012 KT 9999 SCT020 BKN035=
TAF from 9 h 00: 060900 061019 18002KT 0100 FG BKN001 BECMG 1114 2000 BR BKN009 BECMG 1416 20010KT 9999 SCT015 BKN040=

1.7.3. Situation at the diversion aerodrome

During the flight, the crew listened to the ATIS message of Saarbrücken aerodrome. The captured information was:

Wind 1104 knots, visibility 2000 meters- few 200- broken 600 feet- temperature 2.6- QNH 1024- trend becoming visibility 3000 meters- broken 800 feet- expect ILS approach RWY 27- transition level 60- Wind 1104 knots- visibility 2000.

1.8. AIDS TO NAVIGATION

The approach procedure for the CAT II ILS DME for runway 24 is based on following means (see Jeppesen chart appendix 1):

- a VOR/DME DIK 114,400 MHz materialising the IAF and collocated with an NDB 307 kHz
- an ILS/DME ILW 110,7 MHz
- an NDB ELU 368,5 kHz at 5,5 NM from the threshold.

All these equipments were operating normally at the time of the accident.

1.9. COMMUNICATIONS

During the last minutes of the flight, LG 9642 was in contact with the Frankfurt en-route Centre, the Approach Control and the Control Tower of Luxembourg.

The aerodrome operates following radio communications frequencies:

- Approach Control frequency 118.9 MHz
- Control Tower frequency 118.10 MHz

These equipments were operating normally at the time of the accident.

Excerpts from the communications with the different organisations are given below with the CVR time base (Appendix 4 shows the radio communications transcription).

Communications with Frankfurt Centre:

At 8 h 44 min 25 s, Luxair 9642, at FL 140, contacted Frankfurt who asked to route directly to ELU and to maintain the flight level. At 8 h 46 min 43 s, the flight was authorised to descend to level 100, then to level 60 at 8 h 49 min 06 s.

At 8 h 50 min 39 s, the controller transmitted: « Luxair 9642 by request of Luxembourg stop your descent level 90 set course to Diekirch ». The crew acknowledged.

At 8 h 52 min 15 s, the controller transferred the aircraft to Luxembourg Approach Control: « Luxair 9642 for lower and radar vectors contact Luxembourg 118,9 good bye ».

Communications with Luxembourg Approach Control

At 9 h 01 min 25 s, the approach controller asked « Niner six four two turn right heading two two zero to intercept cleared for approach, report established on the localizer ».

At 9 h 02 min 32 s, the crew announced « The Lux euh nine six four two is now established on the localizer ». The flight was then transferred to Control Tower frequency, which was contacted at 9 h 02 min 51 s.

Communications with Luxembourg Control Tower

At 9 h 02 min 57 s, the tower controller replied « Luxair nine six four two gudden Moien, continue approach. The wind is calm RVR beginning two five zero meters, mid section two five zero meters, stop end two two five meters ».

At 9 h 03 min 08 s, the crew replied « … that’s copied Luxair nine six four two… but we need three hundred meters for the approach ».

At 9 h 03 min 18 s, the controller transmitted « Nine six four two copied… uh so continue approach and I’ll keep you advised we didn’t have three hundred uh… uh during the last time ».

At 09 h 03 min 28 s, the crew announced « Euh Roger nine six four two, we keep you advised we’re proceeding to ELU now and … uh standing by nine six four two ».

At 09 h 04 min 57 s, the controller transmitted an RVR of 300 m to the crew: « Luxair nine six four two RVR three hundred meters two seven five meters stop end two seven five meters ».

At 9 h 05 min 05 s, the crew announced « Nine six four two Roger so we continue ».

At 9 h 05 min 08 s, the controller replied « Nine six four two you are cleared to land wind one eight zero degrees….knots».

The co-pilot acknowledged this message at 9 h 05 min 13 s. It was the last communication with ATC.

1.10. AERODROME INFORMATION

The airport has a single runway oriented 241° / 061° of a length of 4000 meters. Altitude of threshold runway 24 is 1214 feet.

The two runway orientations are each equipped with an ILS;

- for runway 06, an ILS category 1,
- for runway 24, an ILS category 3.

The airport is equipped with a primary and a secondary approach radar, used by Approach Control for i.e. radar vectoring on initial and intermediate approach and for separating incoming and outgoing IFR traffic.

The fire protection category of the airport is category 8, in accordance with ICAO Annex 14.

All technical equipments of the airport worked normally.

1.11. FLIGHT RECORDERS

The Fokker 27 Mk050 was equipped with two flight recorders:

	FDR	CVR
Model	Fairchild F800	Fairchild A100A
Reference (P/N)	17M-800-251	93-A100-80
Serial number (S/N)	3672	56866

The recorders have been taken in the afternoon of 7 November to the BEA. Extractions of the tapes and the readings have been done right away.

Final validated data of the CVR and FDR are shown in the appendices 2 and 3.

1.11.1. Read out operations

1.11.1.1. FDR

The recorder, still fixed to its support structure, was in good shape. Inside of the protected box, the tape was in place and in an apparent perfect condition. The reel on which the magnetic tape is rolled inside the recorder has been extracted and placed on an appropriate reading device. This device produces files that faithfully describe the analogue signals registered on the tape, but these files have to be decoded and synchronized by appropriate software.

1.11.1.2. CVR

The cockpit voice recorder was still fixed to its support structure. Not much damaged, its state nonetheless required the box to be cut apart. After extraction, the tape has been transferred onto a new standard reel.
The magnetic tape of the CVR Fairchild A-100 comprises four channels, which correspond to the four channels recorded during thirty minutes.

The reading of the tape has been done on an adapted REVOX reading device, after adjusting the tape speed thanks to the 400 Hz signal corresponding to the onboard power supply. Furthermore, the CVR included on channel 2 an FSK signal (Frequency Shift Keying). This signal is composed of acoustic bips spaced exactly by 4000 ms permitting to fine tune the tape speed. In addition, these bips code UTC time that can be read by a specialised decoding device.

1.11.2. Read out results

1.11.2.1. FDR

Hereafter are listed some significant parameters of the last 30 seconds of the recording.

At 9 h 05 min 00 s: reduction of engine power

- Heading: 239°
- Indicated airspeed: 165 kts
- Pressure altitude: 2742 ft
- Propeller torque (left and right): 17% and 15%
- Propeller speed (left and right): 85% and 85%
- Fuel flows (left and right): 493 lb/h and 447 lb/h
- Flaps position: 0

At 9 h 05 min 09 s: start lowering flaps

- Heading: 240°

- Indicated airspeed: 152 kts
- Pressure altitude: 2 712 ft
- Propeller torque (left and right): 0% and 0%
- Propeller speed (left and right): 85% and 85%
- Fuel flows (left and right): 208 lb/h and 182 lb/h
- Flaps position: 1

At 9 h 05 min 16 s: start lowering landing gear

- Heading: 238°
- Indicated airspeed: 145 kts
- Pressure altitude: 2 635 ft
- Propeller torque (left and right): 0% and 0 %
- Propeller speed (left and right): 85% and 85%
- Fuel flow (left and right): 214 lb/h and 188 lb/h
- Flaps position: 12

At 9 h 05 min 17 s, the left propeller « blade angle » parameter switches from «normal» to «low pitch» [2], signalling a propeller blade angle setting less than 10°.

- Heading: 236°
- Indicated airspeed: 144 kts
- Pressure altitude: 2 617 ft
- Propeller torque (left and right): 0% and 0%
- Propeller speed (left and right): 86% and 86%
- Fuel flows (left and right): 202 lb/h and 174 lb/h
- Flaps position: 12

The right hand propeller[3] «blade angle» parameter switches from «normal»to «low pitch» a second later.

At 9 h 05 min 20 s: start of flaps retraction

- Heading: 237°
- Indicated airspeed: 131 kts
- Pressure altitude: 2 512 ft
- Propeller torque (left and right): 3% and 0%
- Propeller speed (left and right): 86% and 95%
- Fuel flows (left and right) : 352 lb/h and 334 lb/h
- Flaps position: 12

At 9 h 05 min 26 s: last recorded values

- Heading: 244°
- Indicated airspeed: 125 kts

[2] This is a binary parameter, meaning there are only two possibilities: « normal » or « low pitch ».

[3] The sample rate of the low pitch parameter is one time per second. Due to the sample rate, the time difference can be anywhere between a little bit more than zero seconds and just less than two seconds.

- Pressure altitude: 2 145 ft
- Propeller torque (left and right): 0% and 0%
- Propeller speed (left and right): 6% and 98%
- Fuel flows (left and right): 7 lb/h and 352 lb/h
- Flaps position: 0

1.11.2.2. CVR

A complete transcription of the recording has been performed, showing a start at time 08h33min49s and ending at time 09h05min44s. The valid CVR data for the event sequence ends at time 09h05min28s, followed by brief interruptions and starts up again. Duration of the valid data recording is 31min39s.

Communications of the pilots with ATC are in the English language. Communications between the crewmembers and with their company are in the Luxembourg language.

This transcription has then been translated into French and English (see appendix 2).

During the last 30 minutes of the recording, following communications between the pilots are noted:

At 08 h 35 min 15 s, the crew received from ATIS the following RVR: Visibility 100 meters, RVR 250 meters, no change, fog.

At 08 h 41 min 08 s, in contact with Frankfurt radar, they were requested to proceed direct Kirn and descend to flight level one four zero.

At 08 h 44 min 53 s, the co-pilot checked again on the latest weather: ATIS – 0820 wind calm, visibility 100, RVR 250 meters no change, overcast 100, temperature 4, dew point 4 no change.

At 08 h 45 min 08s, the co-pilot remarked that it looked bad with the weather and the captain replied “Dad still works with all the tricks”, and talked about the possibilities of a holding pattern and the RVR evolution.

A 08 h 45 min 45 s, the copilot asked the captain if he wanted to say something about CAT II.

At 08 h 46 min 21 s, the captain asked the co-pilot if he had spoken already to the passengers. His reply was no and there was an uncertainty who should do it, the pilot flying or the pilot not flying. Since the co-pilot was handling the radios, the captain told him to make the announcement to the passengers, but nobody was sure of what to say.

At 08 h 47 min 32 s, the captain decided to call Luxair Dispatch to find out the latest status of the RVR.

At 08 h 47 min 57 s, Dispatch reported that the RVR was 250 for the moment and that it had been quite a while since it was 300, and that if it wouldn’t improve, they would be diverted to Saarbrücken.

At 08 h 48 min 35 s, the captain asked Dispatch again if there was a Cargolux taking off in the near future.

At 08 h 49 min 25 s, the crew expressed their discontent to be diverted to Saarbrücken and the captain listened to the Saarbrücken ATIS.

At 08 h 50 min 41 s, Frankfurt Control requested them to stop descend at flight level nine zero and to set course to Diekirch.

At 08 h 51 min 42 s, the co-pilot debated again on what to tell the passengers and on initial contact with Luxembourg approach at 08 h 52min 49s he was told to enter Diekirch holding, flight level nine zero, it will be vectored later on for ILS two four, Cat two on two four, QNH one zero two three, current RVR beginning 250 meters, mid 275 meters and stop end 225 meters.

At 08 h 53 min 36s, the co-pilot started his announcement to the passengers first in Luxembourg language, then German and finally in English by letting them know that they would go into a holding pattern and wait for weather improvement.

At 08 h 54 min 43 s, the captain told Luxembourg radar that he was reducing speed to one six zero.

At 08 h 56 min 44 s, the co-pilot asked the cabin crew if his announcement did make sense.

At 08 h 58 min 12 s, the crew talked about the fuel on board and on how much they needed for the holding and the diversion.

At 08 h 58 min 50 s, Radar Control requested them to descend to three thousand feet on one zero two three and to turn left heading one three zero.

At 08 h 59 min 35 s, the captain asked the co-pilot about the latest RVR. Since the co-pilot did not know.

At 09 h 00 min 22 s, the captain called Dispatch again for the latest RVR, which was 275 meters. Upon this he asked the co-pilot: what are we going to do now, who replied: I don’t know.

At 09 h 00 min 50 s, the crew listened to a message from ATC given to another aircraft about the RVR status of 275 / 275 / 255 meters.

At 09 h 01 min 06 s, the copilot questioned: what will they do with us then, Holding or Approach, upon which, the captain replied: that it is for an approach.

At 09 h 01 min 15 s, the co-pilot mentioned that the Cargolux should make a go-around in order to clear up the fog, so they could land.

At 09 h 01 min 25 s, ATC told the crew: turn right heading two two zero to intercept, cleared for approach, report established on localizer.

At 09 h 01 min 42 s, after having been cleared for approach, the co-pilot remarked that the controller took them in ahead of other aircraft (then in the Diekirch hold).

At 09 h 02 min 09 s, the captain announced *« Loc ass alive an captured »* (Loc is alive and captured).

At 9 h 02 min 12 s, the captain said: tell him (ATC) that if at Echo we don't have 300 meters, that we then do a go-around and fly to Diekirch.

At 9 h 03 min 04s, after the transmission of the last RVR information, the captain said twice *« Oh, dat brengt neischt »* (Oh, this doesn't bring a thing), and at 9 h 03 min 16 s, he added *« So, mir gin weider fir bis ELU, wa mir dann neischt hätten, dann ehhhhhhh »* (Tell them, we continue to ELU, if we have nothing, then ehhh).

From 9 h 04 min 30 s to 9 h 04 min 53 s, the crew performed the before approach checklist.

At 9 h 04 min 46 s, the captain announced to the co-pilot *« Yo, bon mir machen en go around, missed approach »* (Yes, well we do a go-around, missed approach).

At 9 h 04 min 57 s, the controller transmitted an RVR of 300 meters for the beginning of the runway.

At 9 h 05 min 00 s, rotation speed of the turbines varies. A sound corresponding to the lifting of the ground range selectors was heard. Consequently and during an interval of sixteen seconds, flaps were extended and the landing gear lowered.

At 9 h 05 min 02 s, the co-pilot said *« geet net duer»* (will not be enough/sufficient).

At 9 h 05 min 08 s, the crew was cleared to land.

At 9 h 05 min 17 s, one second after the landing gear started to come down, an increase of rotational speed of at least one propeller was perceived, then numerous noises of selections and power variations were heard.

At 9 h 05 min 19 s, the captain said « *Waat ass dat??»* (What's that).

At 9 h 05 min 27 s, the beginning of a GPWS alarm appeared, one second later the CVR stopped.

Two portions of recording were then noted, one of 0,9 second duration, the other of 0,7 second duration and separated by 11,2 seconds and representing recorded portions from the beginning of the CVR and not newly overwritten.
At no moment of the flight, the crew mentioned any failure of aircraft systems.

1.11.3. Correlation with radar recordings

The recordings from the Luxembourg radar were available in the usual Asterix format. A conversion of this file into an exploitable Rho / Theta format has been performed, which can easily been analysed by standard tabulation software.

Vertical and horizontal plots of the aircraft's trajectory during the last minutes have been drawn and are shown in appendices 16 and 17.

1.12. WRECKAGE AND IMPACT INFORMATIONS

1.12.1. Site description

The aircraft touched down approximately on a heading of 295°, as indicated by the general direction of the debris. The first impact marks are found on the south edge of the road RN1. They represent the two main landing gears and the fuselage tail cone.

Scraping marks on the road, notably from the left wing tip show that the aircraft scratched across the road before hitting an embankment at the north side of the road RN1.

Aerial view of RN1 and the site

The major part of the damage results from this blow during which the aircraft lost three blades from the right propeller and two from the left propeller, wheels from the left and right landing gear.

Furthermore, the aft portion of the fuselage was disrupted at the trailing edge of the wings by this shock.

After this bounce, the empennage and part of the right outboard wing broke away, the aft portion of the fuselage turned around and the aircraft came to rest 25 meters further away in a field.

Aerial view of the right hand side of the aircraft

Aerial view of the left hand side of the aircraft

1.12.2. Wreckage examination

Note: The investigators have done the observations listed below. It is possible that certain observations do not correspond to the situation before impact as through the shock or through some rescue operations, lever positions may have been affected.

Exterior:

The fuselage and the wings remained attached. The aft portion of the fuselage, including the rudder and the horizontal stabiliser, was detached from the aircraft. The flight data recorders were ejected by impact and found close to the detached aft portion of the fuselage. On the fuselage a more important deformation is noted on the right hand side as compared to the left side. The central part of the fuselage was burnt.

The flaps (left and right wing) are retracted. The main landing gears have been ripped out.

The engines suffered light damage, except the lower parts that were in contact with the ground. On the left hand side, all propeller blades are broken at their root. On the right hand side, three propeller blades out of six remain attached to the hub. All blades, of composite construction, are damaged. Some are delaminated and others are totally destroyed.
Blade pitch angle of the LH propeller is close to feather. Blade pitch of the RH propeller is in the beta range.

No damage has been detected on the parts exposed neither to the relative wind nor in the engine intakes, which may be attributed to bird impact.

Cockpit:

Power lever positions are not relevant, as all cables have been stretched and rescue services were active in this area to retrieve the pilots. Left and right fuel levers are in OPEN position.

Elevator trim position is incoherent with the trim tab position. As for the power levers, its position may have been affected by traction or rupture of the cables and by the rescue operations.

Rudder trim position is five units to the left. Flaps selector is in the OFF position.
The Ground Idle Stop selector is in the OFF position.

- Left instrument panel

  Altimeter indicates 998 feet, and is set to 1023 hPa. The stand-by altimeter shows 690 feet and is set to 1037 hPa.

  The speed indicator shows 110 kts, the speed bug is positioned at 101 kts. The stand-by speed indicator shows zero kts.

- <u>Central instrument panel</u>

  The two engine parameters (propeller speed, HP turbine RPM and turbine temperatures) are close to zero. The RPM indicator of the LP turbine shows 92% for the two engines.

  Brake pressure indicator and fuel totaliser show zero.
  The two engine torque indicators show 25% (minimum reading of the indicators and powered down position), the OFF flag being apparent.
  The temperature and oil pressure indicators show zero.
  Landing gear selector is in the DOWN position.

- <u>Left instrument panel</u>

  The speed indicator shows 125 kts, with the speed bug positioned at 91 kts.
  The altimeter indicates 380 feet and is set to 1023 hPa.
  The RMI indicates 295°, the single needle shows 080°and the double needle shows 295°.

- <u>Glare shield panel</u>

  The left and right EFIS are switched to mode NAV.

- <u>Overhead panel</u>

  Landing lights, taxi lights, anti-collision lights, navigation lights, strobes, non-smoking sign and fasten seat belt sign are «ON».

  The handles of the engine fire extinguishers are not pulled. The fire loop push buttons are in the normal position.

  The ignition switches LH and RH of the Engine Control Panel are in the «ON» position.

  The PEC switches are in position « NORMAL » (PEC's are operational).
  Fuel pump switches are « ON ».
  Hydraulic pump switches are « ON ».
  Cockpit windshields and pitot heating switches are « ON ».
  Engine anti-icing is « ON », wing anti-icing is « OFF ».

1.13. MEDICAL AND PATHOLOGICAL INFORMATIONS

The results of the analysis performed on the blood samples taken from the pilots did not show any evidence that could have affected their ability to control the aircraft.

1.14. FIRE

When the aircraft came to a halt, a fire started and destroyed the central part of the fuselage.

1.15. SURVIVAL ASPECTS

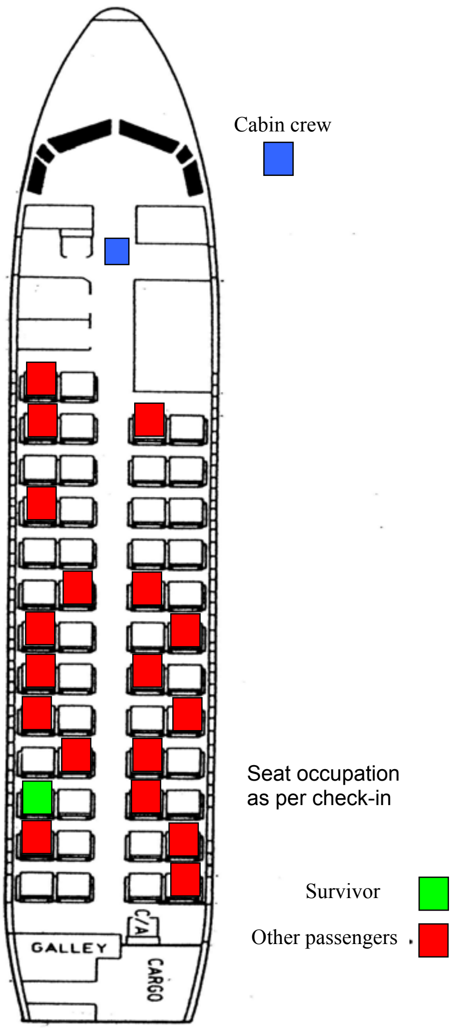
The layout shown hereafter represents the seating as known from the check-in. It does not necessarily reflect the actual seating. Considering the number of passengers, the possibility exists that one or the other passenger may have been seated on a different seat as shown by the check-in seating.

The aircraft hit the embankment with the aft portion of the fuselage (behind the trailing edge of the wing), this part being partially disrupted and turned over 90° to the right (in flight direction)

At 9 h 06, a witness notified the accident to the national emergency centre. On site intervention of the fire brigade started at 9 h 18 after positioning of the fire engines.

Rescue services found passengers, ejected from the fuselage, behind the left wing. Some passengers were still attached to their seat and others were not. The cabin crewmember was found in the corridor next to the fuselage front entrance. The captain wore his full harness, the co-pilot only his ventral belt.

The cockpit did not burn and a hole was cut in the fuselage to retrieve the captain who survived. Only one of the ejected passengers survived.



1.16. TESTS AND RESEARCH

1.16.1. Complementary flight recorder analyses

1.16.1.1. FDR

The experts from the BEA have performed further detailed analyses in order to validate the initial findings.

It was confirmed that from the 6 channels of the FDR, one channel could not be completely exploited. However this did not concern the accident flight, which is entirely available on the recorder. The end of exploitable information was confirmed to be time 9 h 05 min 26 s (this last second included).

1.16.1.2. CVR

1.16.1.2.1. Noise identification

It was concluded from the initial CVR readout report that additional tests were necessary. These tests were conducted by the CVR experts from BEA with the aim to validate the hypotheses based upon the transcriptions of the noises and alarms recorded on the CVR.

In order to reproduce similar conditions to those during the accident, several tests were performed:

- The same type of CVR (a magnetic tape A100-A) was used on every aircraft used to perform the tests. This was also the type of CVR installed on the crashed aircraft.
- A Luxair Fokker 27 Mk050 registered LX-LGC flew from Paris to Luxembourg with a safety investigator present in the cockpit.
- Following this flight, the CVR was removed from the aircraft for read out and analysis of noises and alarms.
- The same aircraft was used for a ground recording.
- Finally, the same tests were recorded in the Fokker 27 Mk050 LX-LGD in order to compare the results with a wider range of aircraft.
- During the tests, the air conditioning was turned on to recreate the main background noise generally heard on CVRs.
- Tests were performed several times on each aircraft in order to compare the transcribed noises with several samples.

Identification and analyses of the relevant noises are found in appendix 17 to this report. The main conclusions are as follows:

- The tests, made on two Luxair Fokker 27 Mk050, were used to compile a large number of noises in order to compare them to those recorded on LX-LGB. The tools available to identify them showed some characteristics of these noises, such as their duration, their rate and the main distribution of the frequencies. During analysis, it is important to note that the tests were recorded on the same type of aircraft, though different from the accident aircraft. Background noises may vary with the aircraft's speed, its engine parameters, and flight configuration (flaps, propeller pitch, landing gear). Moreover, each switch or lever on the aircraft can have its own characteristics, different from those of the same part on another aircraft.

- This analysis nevertheless gives the following results:

Time on the Transcription	Hypothesis	Result
09 h 04 min 58s	Ground Idle Stop movement	Probable
09 h 05 min 00s	Lift of the Ground Range selector	Positive
09 h 05 min 09s	Flaps control	Positive (towards 10°)
09 h 05 min 11s	Taxi Lights switching on	Positive
09 h 05 min 19s	-	Noise of the ground idle position (positive)
09 h 05 min 21s	Flaps control	No identification possible
09 h 05 min 27s	-	No identification possible

To conclude, it must be pointed out, that as far as the movement of the ground idle stop is concerned, the result of the noise analysis is strengthened by the fact, that at time 09:04:53, the co-pilot says "ground idle stop off", this being the last item of the BEFORE APPROACH checklist.

1.16.1.2.2. CVR and radar trajectory synchronisation

The recordings contain dating information from different sources.

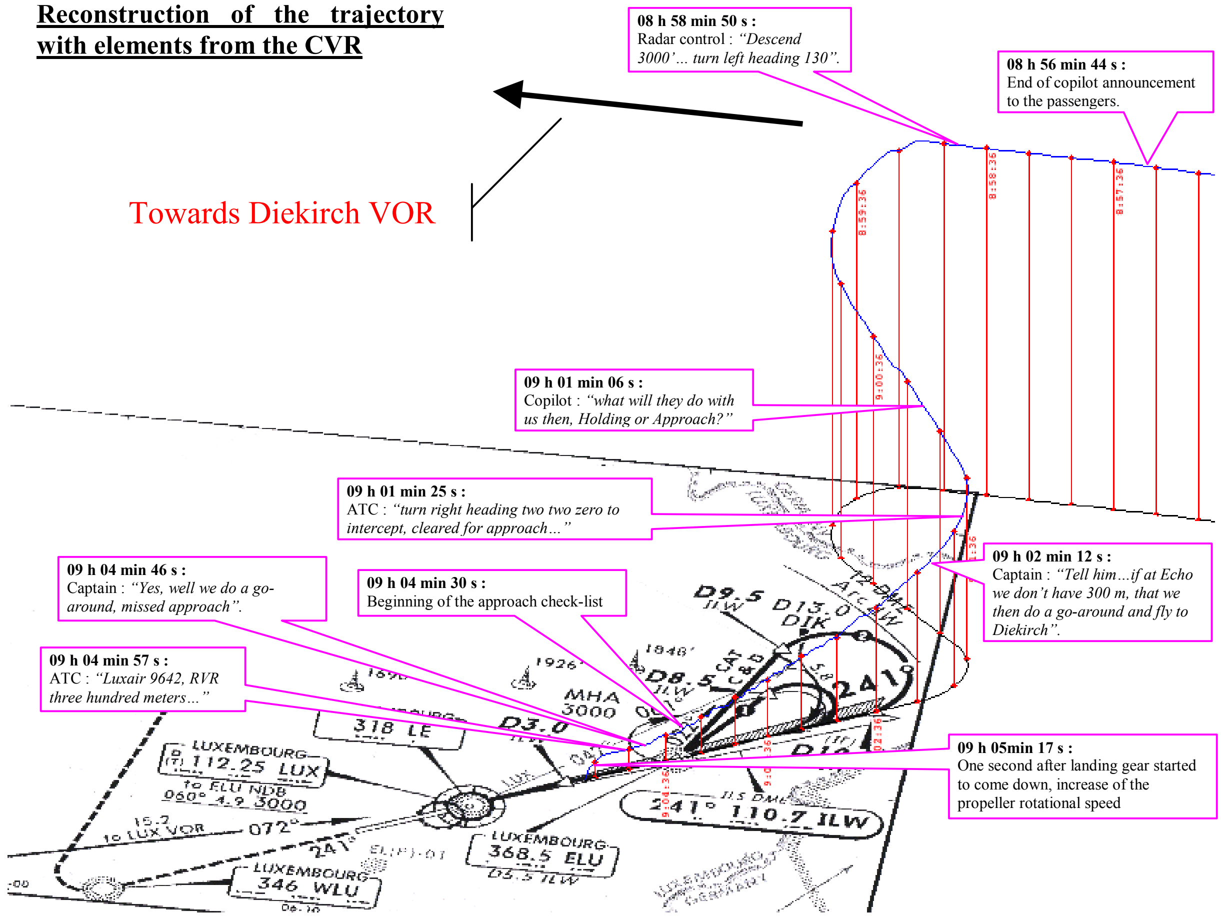
- The time basis of the CVR recording is the FSK signal (recorded every 4 seconds) which source comes from the onboard clock. The FDR records the "hour", "minute" and "seconds" parameters that also come from the onboard clock.
- Time information registered on the radar recordings comes from the standard airport GPS clock.

The altitude information allowed a time correlation between the radar recording and the FDR recording. In fact, the pressure altitude taken into account by the aircraft calculators is recorded on the FDR every second. It is simultaneously transmitted by the transponder under flight level format (altitude rounded up at 100 ft) and registered by the radar station, roughly every 4 seconds. Since the radar record and the FDR record have the same source for the pressure altitude, one can correlate their base time by relating the vertical approach profile obtained by these recordings. (Appendix 17 – vertical plot of the trajectory)

The precision of these correlations is estimated at a few seconds, because of the flight level resolution of 100 ft and the sampling of the radar period of about 4 seconds.

The good correlation between the FDR recording and the CVR recording has been verified by the binary parameter "transient ident" which is active during the communications of the cockpit crew and the ATC. This parameter is recorded every second and the precision of this correlation can be estimated by one second.

From the CVR recordings and elements from the radar trajectory, a flight path showing the last phase of the flight has been made up.



This three dimensional trajectory has been made up on the basis of Luxembourg radar data. Synchronisation precision between FDR and CVR is one second.

The vertical profile of the trajectory shown in appendix 17 represents radar data illustrating that the final descent of the aircraft started markedly after the ELU beacon.

1.16.2. Propeller regulation systems

1.16.2.1. General

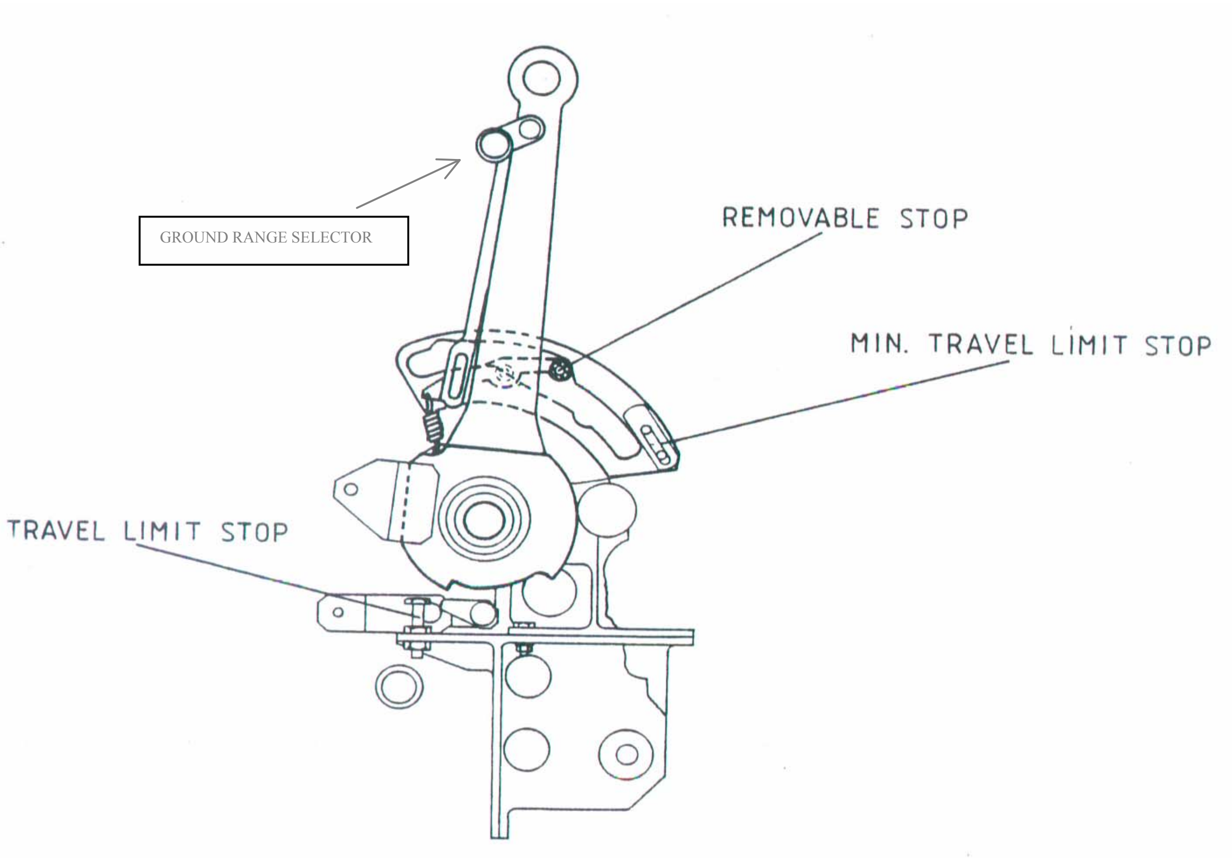
The engine drives a variable-pitch, constant-speed propeller with six blades. A propeller speed indicator is located at the centre main instrument panel. Two possibilities exist to control the propeller:

- Above flight idle, constant speed control is regulated automatically in flight.
- On the ground, below flight idle and in the beta mode range, propeller pitch is directly controlled by the power lever position.

The actual blade angle at which the propeller produces zero thrust (torque) depends on the rotational speed of the propeller and the forward speed. At a blade angle of approximately 26 degrees, the aerodynamic force tends towards zero and starts acting backwards if propeller pitch is further reduced.

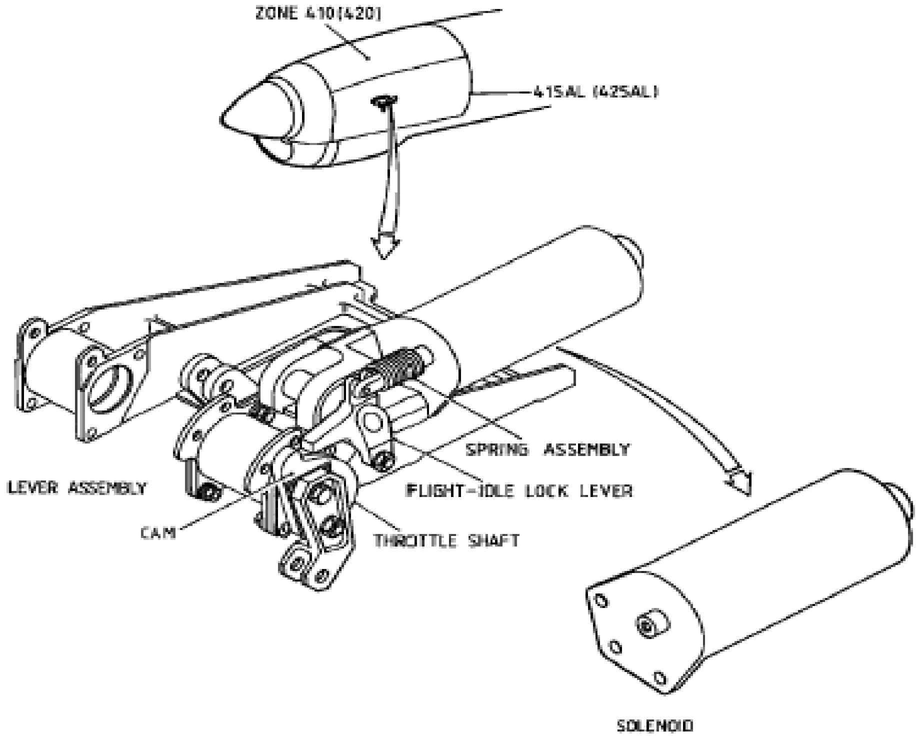
In flight, power lever positions below flight idle are prevented by two means:

- a mechanical primary stop (ground range selector) on the power levers



Power levers and ground range selector

- an electrical secondary stop (flight idle stop solenoid) on each engine.



To select the beta mode after landing, with the power levers in the flight idle position one has to grab and lift the ground idle selectors fixed to the power levers and move the levers backward. This first mechanical stop on the power levers is doubled by a flight idle stop fixed to each engine and activated by solenoids.

Once the solenoids are powered up, the flight idle stops are released and power levers may be moved backwards below the lever range for flight.

Power supply to the solenoids is assured when:

- one of the sensors mounted on the shock absorbers of the left and right main landing gear detects a compression of the shock absorber during landing, or

- the two wheel speed sensors mounted in the wheel axles on one main landing gear detect a wheel speed in excess of 17 kts.

1.16.2.2. Constant speed control

Above flight idle, the Propeller Electronic Control unit controls propeller speed by varying the blade angle.
Speed is controlled to 100% during take-off, maximum continuous and go around power settings. Propeller speed is controlled to 85% during climb and cruise.
Propeller synchronizing is totally automatic.

1.16.2.3. Propeller pitch

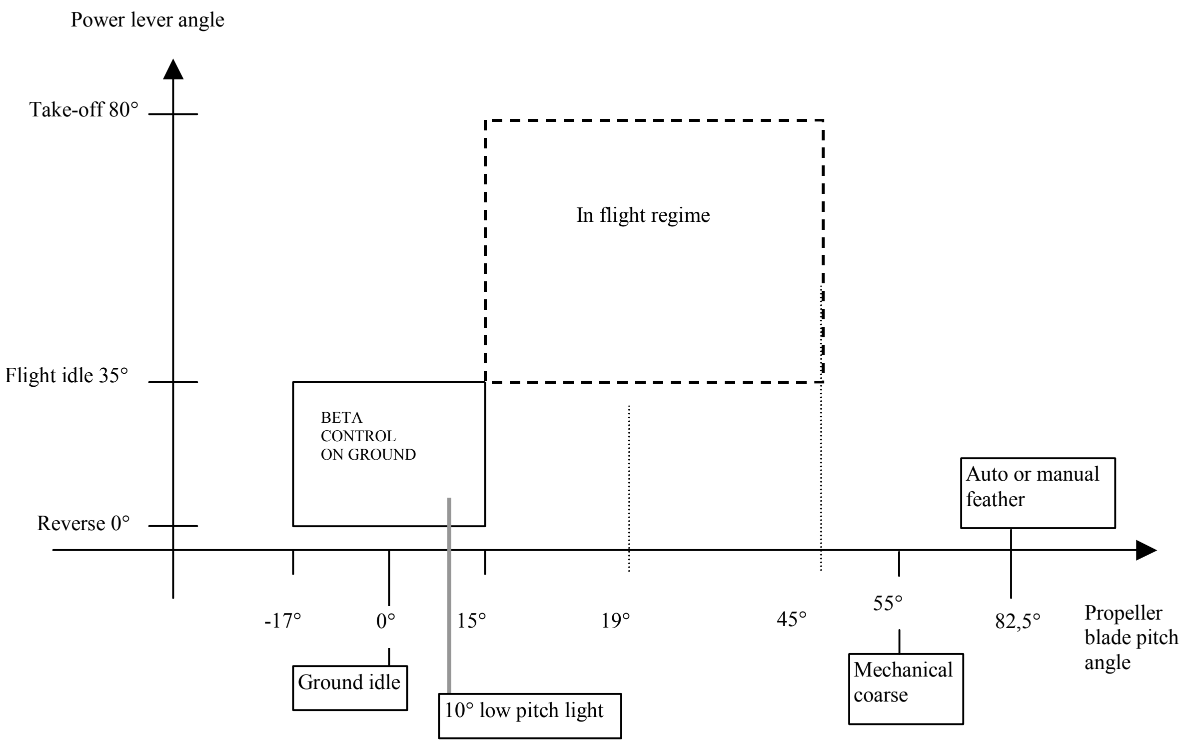
Propeller pitch angle varies in flight from + 15 degrees to approximately + 45 degrees. Propeller pitch is controlled by balancing oil pressure against the coarse seeking force that results from the counterweights, which are attached to the roots of the blades.

A gearbox driven high-pressure pump, driven by the propeller gear box and being part of the overspeed regulation and supplied with engine oil, provides the required oil pressure. In the event of an oil pressure loss, the counterweights will move the blades to an angle of + 55 degrees, thus eliminating propeller overspeed and minimising the drag created by the wind milling propeller. The dedicated drive of the high-pressure pump assures control as long as the propeller is wind milling.

In case of an in flight engine failure, the propeller regulating mechanism initially tries to maintain a constant speed of the propeller in relation to the indicated airspeed until it is feathered either automatically or manually.

1.16.2.4. Control in mode beta

Below flight idle, the power lever controls propeller pitch directly from about a blade angle of + 15 degrees to -17 degrees (full reverse).



In the beta mode, the commands of the propeller electronic controls are inhibited. Propeller blade angles are then solely controlled by the movement of the power levers (power lever angle).

A blue low pitch light, located on the central instrument panel, comes on when the blade angle drops below 10°.

1.16.2.5. Overspeed protection

In flight, a propeller overspeed governor comes into operation when propeller speed reaches 104 percent. The gearbox-driven governor reduces the oil flow to the pitch changing mechanism.
If there is no propeller speed reduction, the propeller speed reaches 108 percent and the overspeed governor intervenes directly in reducing fuel flow. On the ground, with the propeller in mode beta, overspeed protection is accomplished at 108% by reducing the fuel flow

1.16.2.6. Feathering system

The propeller can be feathered automatically or manually. The propeller is feathered manually when the fuel lever is set to SHUT or START. The feathering pump is activated when:
- the autofeathering system is activated when the aircraft is on the ground or in flight, or
- when the fuel lever is set to SHUT or START when the aircraft is in the air.

The feathering pump brings the blade pitch angle to a position of 82 degrees, minimizing thereby aerodynamic drag (feathered propeller).

1.16.3. Antiskid control system

The antiskid system gives optimum brake operation for all runway conditions and operates on the normal brake system only. The system's main components are:

- A antiskid control unit
- Four wheel speed sensors
- Two antiskid control valves

The system uses also:

- The integrated alerting unit (IAU)
- The flight compartment test panel
- The GND/FLT relays
- The towing switch relays
- The main landing gear up-lock switches

The dual electric power supply to the skid control unit is via both main gear uplock switches in the landing gear down sequence as soon as the uplocks are released.

The antiskid control unit receives input signals from the wheel speed sensors and gives outputs to the antiskid control valves to control the main wheel brake pressures. The antiskid control unit has three operational modes, anti-skid, locked wheel protection and touch down protection.

a) the antiskid mode is activated at wheel speeds above 10 kts (12mph). The antiskid control unit will detect a deceleration of one or more wheels. The relevant antiskid control valves will reduce the brake pressure in relation with the rate of deceleration.

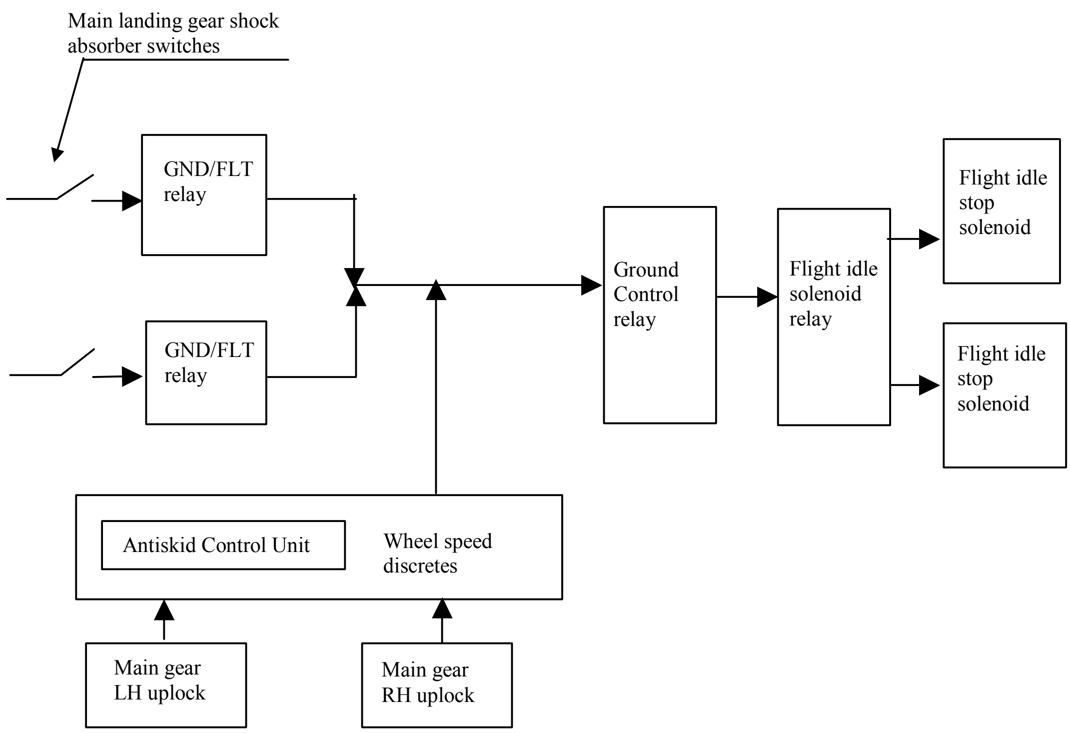
b) The locked wheel protection mode is active at speeds above 17 kts (20mph). When the speed of a wheel decelerates to a point where it may lock, brake pressure is fully released to allow the wheel to spin up again.

c) The touch down protection mode releases all pressure from the brakes in flight with the landing gear down and for a period of seven seconds after touch down in case of no wheel spin-up (e.g. due to hydroplaning). When a wheel speed is above 30 kts, the full dump current to the relevant valve is stopped. From this moment antiskid control is in operation for that wheel.

The antiskid control unit monitors the dual electric power supply inputs and the ground/flight relay inputs. When a difference in a pair of inputs occurs for more than 15 seconds, a signal is sent to the integrated alerting unit (IAU). The related magnetic indicator on the antiskid control unit identifies the failure.

The wheel spin-up signals or the GND/FLT relays switches energise the flight idle stop solenoids through the ground control relay. The antiskid control unit senses the wheel spin-up signals. The main gear switches initiate the transmission of GND/FLT signals.

The following illustration shows, how these signals are carried to the flight idle stop solenoids.



Power up of the skid control unit is via the main gear uplocks switches.

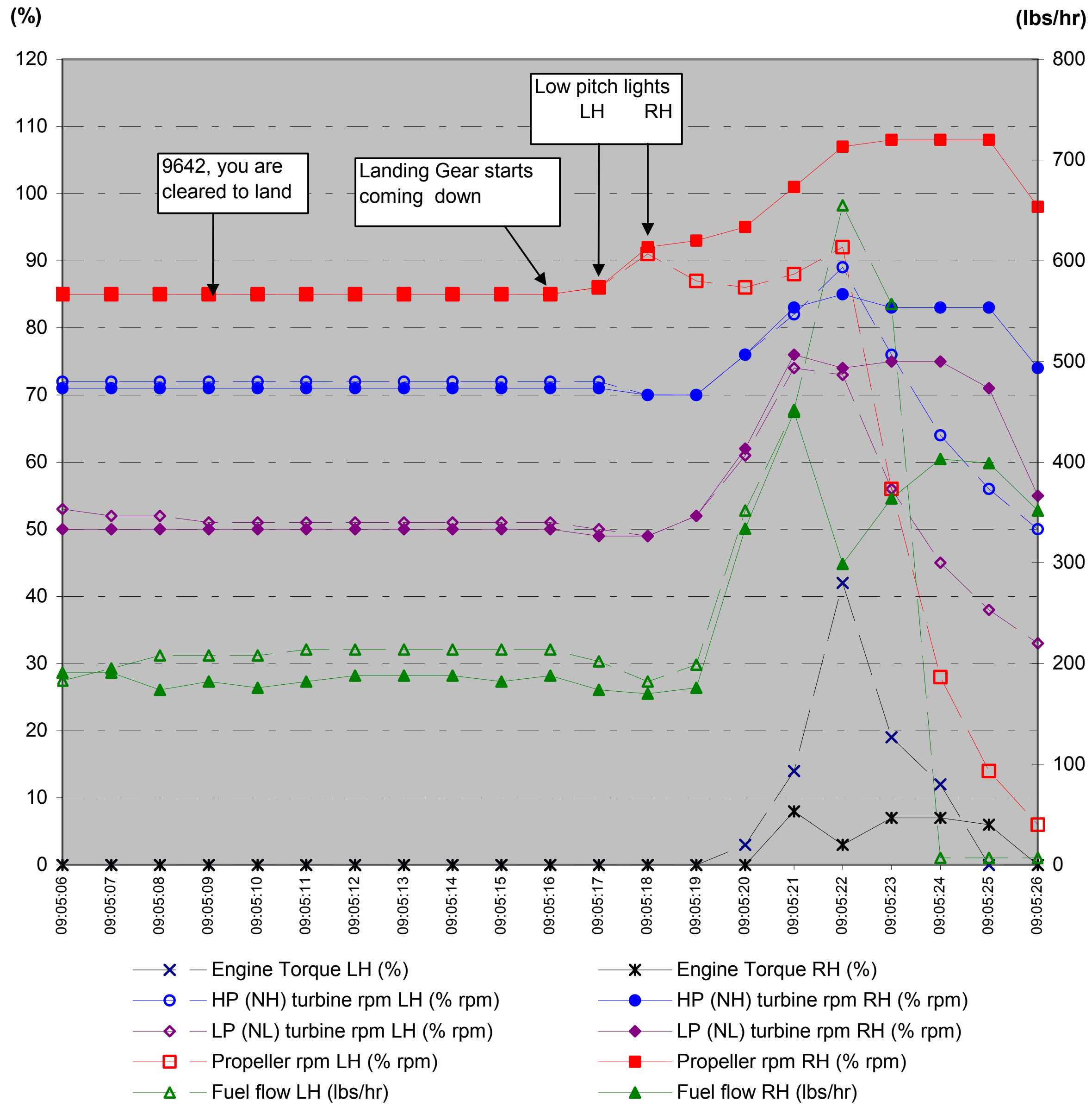
1.16.4. Interpretation of recorded engine parameters

For the last 20 recorded seconds, from time 09 h 05 min 06 s to time 9 h 05 min 26 s, the relevant engine parameters are shown in following table.

LGB	Engine		Fuel		HP (NH)		LP (NL)		Propeller	
	Torque LH (%)	Torque RH (%)	flow LH (lbs/hr)	flow RH (lbs/hr)	turbine rpm LH (% rpm)	turbine rpm RH (% rpm)	turbine rpm LH (% rpm)	turbine rpm RH (% rpm)	rpm LH (% rpm)	rpm RH (% rpm)
09:05:01	4	4	283	261	81	80	66	66	85	85
09:05:02	0	0	207	202	77	77	61	61	85	85
09:05:03	0	0	183	179	75	74	58	57	85	85
09:05:04	0	0	160	191	73	72	55	53	85	85
09:05:05	0	0	177	173	72	71	54	51	85	85
09:05:06	0	0	183	191	72	71	53	50	85	85
09:05:07	0	0	195	191	72	71	52	50	85	85
09:05:08	0	0	208	174	72	71	52	50	85	85
09:05:09	0	0	208	182	72	71	51	50	85	85
09:05:10	0	0	208	176	72	71	51	50	85	85
09:05:11	0	0	214	182	72	71	51	50	85	85
09:05:12	0	0	214	188	72	71	51	50	85	85
09:05:13	0	0	214	188	72	71	51	50	85	85
09:05:14	0	0	214	188	72	71	51	50	85	85
09:05:15	0	0	214	182	72	71	51	50	85	85
09:05:16	0	0	214	188	72	71	51	50	85	85
09:05:17	0	0	202	174	72	71	50	49	86	86
09:05:18	0	0	182	170	70	70	49	49	91	92
09:05:19	0	0	199	176	70	70	52	52	87	93
09:05:20	3	0	352	334	76	76	61	62	86	95
09:05:21	14	8	452	450	82	83	74	76	88	101
09:05:22	42	3	655	299	89	85	73	74	92	107
09:05:23	19	7	557	364	76	83	56	75	56	108
09:05:24	12	7	7	403	64	83	45	75	28	108
09:05:25	0	6	7	399	56	83	38	71	14	108
09:05:26	0	0	7	352	50	74	33	55	6	98

Time 09:05:26 is the last valid record of the DFDR.

These values are transposed into the following diagram, allowing subsequent analysis.



According to the engine manufacturer's information, the HP (NH) values for Flight Idle in flight are 74%. Flight Idle corresponds to zero torque, which is easily recognized for the recorded engine parameters. It can be noted that the engines never stabilised on this setting.

Analysing all the data recorded from the FDR, this HP value of 74% can be found for all flights where the engines are on flight idle with a zero torque value.

Up to 09:05:00, the power settings are consistent for the horizontal flight portion at 3000 ft QNH whilst passing ELU.

At 09:05:02, propeller torque is zero and HP indicating 77%, which during the next seconds drops to 72% for the LH engine and 71% for the right hand engine, values recorded at time 09:05:17.

With these engine speed readings, the propeller blade angles were between 15° and 10°; this coinciding with a power lever position below flight idle, 15° being the minimum setting for flight idle and 10° being the limit for the low pitch light.

At 09:05:17, the low pitch parameter of the LH propeller switched to low pitch.
A second later, at 09:05:18, the low pitch parameter of the RH propeller switches to low pitch.
At this time both HP values had dropped to a minimum reading of 70%.

The low pitch light only comes on, when the propeller blade angle is below 10°. Until they came on, the propeller RPM where stable at 85%, which is the normal setting for cruise and climb sectors.

At 09:05:19, reverse power was applied to both engines, which is documented by a rapid increase of all engine parameters.

Some time after this moment, the power levers were set beyond the flight idle position back into the flight range. On the CVR, no related noise can be identified. Such a lever movement noise is most probably submerged within the intense level of noise in the cockpit at that moment. (see appendix 22 for a detailed description of this phase)

At 09:05:22, whilst the LH and RH propeller speeds had further increased, the LH engine was shut by putting the fuel lever in the SHUT position.

At 09:05:23,4 the LH propeller RPM drops below 50% and the LH generator is taken off-line by the generator control unit (GCU). The RH generator now powers all electrical buses. This is consistent with the fact that at that moment the CVR records a noise similar to an electric transfer.

At 09:05:25, the LH engine HP drops below 60%. No alert level 3 triple chime was recorded on the CVR, confirming that the engine was shut down manually.

This can be reasonably said, as in order for the propeller to go to feather in flight, three conditions must exist, namely:

- the power lever is in the flight range,
- the GND/FLT signal is FLT mode,
- and the fuel lever not in OPEN position.

(see appendix 22)

The left hand propeller was found to be in the full feathered position.

With the left hand propeller going into feather, the brake effect of this propeller started to decrease.

At 09:05:25, the RH propeller speed had reached to 108% RPM. This represents the maximum value allowed by the overspeed governor of the propeller. At this time, the RH engine was shut down, by putting the fuel lever in the SHUT position.

At time 09:05:26, the last valid record, both fuel levers are in the SHUT position.

However, with all three preceding conditions still existing, the right hand propeller did not feather, possibly because of the following reasons:

- The right hand propeller was too far in the reverse range,
  In this particular case and with the power lever repositioned in the flight range, the beta tube was hydraulically isolated and the delivered pressure was not available to reposition the propeller into a positive blade angle.

- The propeller manufacturer stated that if the propeller blade angle was below – 4 degrees, the resultant force acting on the propeller blades, would put the propeller in full reverse. With the power lever in ground idle position (beta range), the blade angle is approximately zero degrees. In view of all registered parameters and considering that the blade angle is –17 degrees for full reverse, it can be said that the propeller blade angle was below –4 degrees when the engine was shut down.

The right hand propeller was found in the full reverse position. (see appendix 22)

1.16.5. Examination of aircraft components

Following components and equipments have been removed from the wreckage for close examinations. All examinations and tests have been done in the presence of the investigation team.

1.16.5.1. Engines

Before removal of the engines from the wreckage, the totality of the engine command rods and bellcranks were checked with appropriate rigging pins. All riggings were found to be conforming to specifications.

Furthermore, as no deviations of the engine parameters during normal flight operation have been observed, the possibility of misrigging of the engine controls can be ruled out.

The PW125B engines were then removed from the wreckage and sent to the manufacturer. All steps of the investigation were documented and photographed.

The evaluation of the accessories from both engines revealed only minor deviations, which were not considered to have prevented the proper operation of the engines. Both engines displayed contact signatures to their internal components consistent with engine producing little or no power at the time of impact. There were no indications of any pre-impact anomalies or distress that would have precluded normal engine operation prior to impact.

The engines producing little or no power at the time of impact is consistent with the data recovered from the FDR, which shows a sharp fuel flow decrease down to zero on the LH engine at time 09:05:23. The last valid recording also shows that both fuel cut-off levers were in the “closed” position suggesting that both engines were shut down prior to impact. This is also consistent with the fact that the debris found within the combustion section of both engines did not show any evidence of charring or burning, indicating that no combustion was taking place at the time of impact. The ingestion of these debris was most likely caused by the fact that, although the engines were shut down, the LP compressors were most likely still rotating at the time of impact. This is the result of the run down time of the LP compressor (minimum of 180 sec required) being longer than the time between the fuel cut-off and the time of the impact (approximately 20 seconds for the LH engine and 15 seconds for the RH engine, considering approximately 15 seconds of missing data between the end of the valid recording and the time of impact).

1.16.5.1.1. Left Hand Engine Examination

This engine had received a hot section inspection at 15,787 total hours on 13 June 2000. Hours since overhaul were 9,099 and cycles since overhaul were 9,794.

The propeller control unit, airframe generator, airframe hydraulic pump and electrical feathering pump had been removed prior to shipment. The wiring harness airframe connections had been cut to facilitate the removal from the airframe.

The left hand engine showed no structural damage. Light circumferential scoring was noted on the Low Pressure (LP) impeller. No scoring or rubbing was noted on the hot section components that would indicate damage beyond expected normal deterioration. All rotors were free to turn and all examined bearings were in good condition. Some ingested dirt, wood chips and airframe debris were found throughout the compressor and combustion sections of the engine. None of this debris however, showed evidence or burning or charring.

1.16.5.1.2. Right Hand Engine Examination

This engine had received a hot section inspection at 16,640 total hours on 13 June 2000. Hours since overhaul were 8,038 and cycles since overhaul were 8,247.

Structural damage to the right hand engine was limited to an impact fracture of the oil tank. Light circumferential scoring was noted of the power turbines and LP impeller. All rotors were free to rotate and all examined bearings were in good condition. No damage was noted on the hot section components beyond expected operational wear. As on the left hand engine, ingested dirt, wood chips and airframe debris were found throughout the compressor and combustion sections of the engine. None of this debris however, showed evidence of burning or charring.

1.16.5.1.3. Electronic Engine Control (EEC)

An engine electronic control unit controls each engine. Both units were taken to their manufacturer for testing. The EEC is a single channel digital Electronic Engine Control in conjunction with a mechanical fuel control (MFC). It monitors and adjusts the power of the engine.

Both units passed their functional tests and no malfunctions were identified.

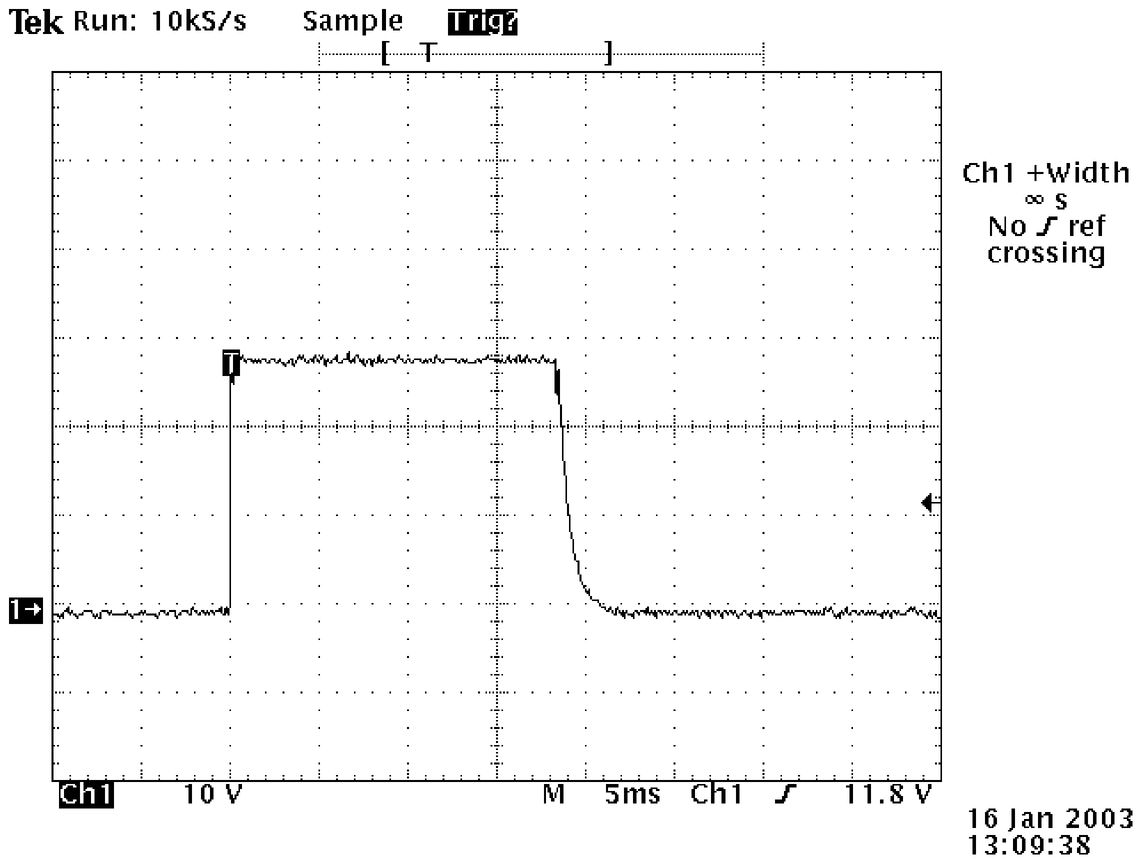
1.16.5.2. AntiSkid Control System

The antiskid control unit (Part number 6004125/ Serial number AUG89-084) and the four wheel speed sensors (part number 6004123-1) were shipped to their manufacturer and tested.

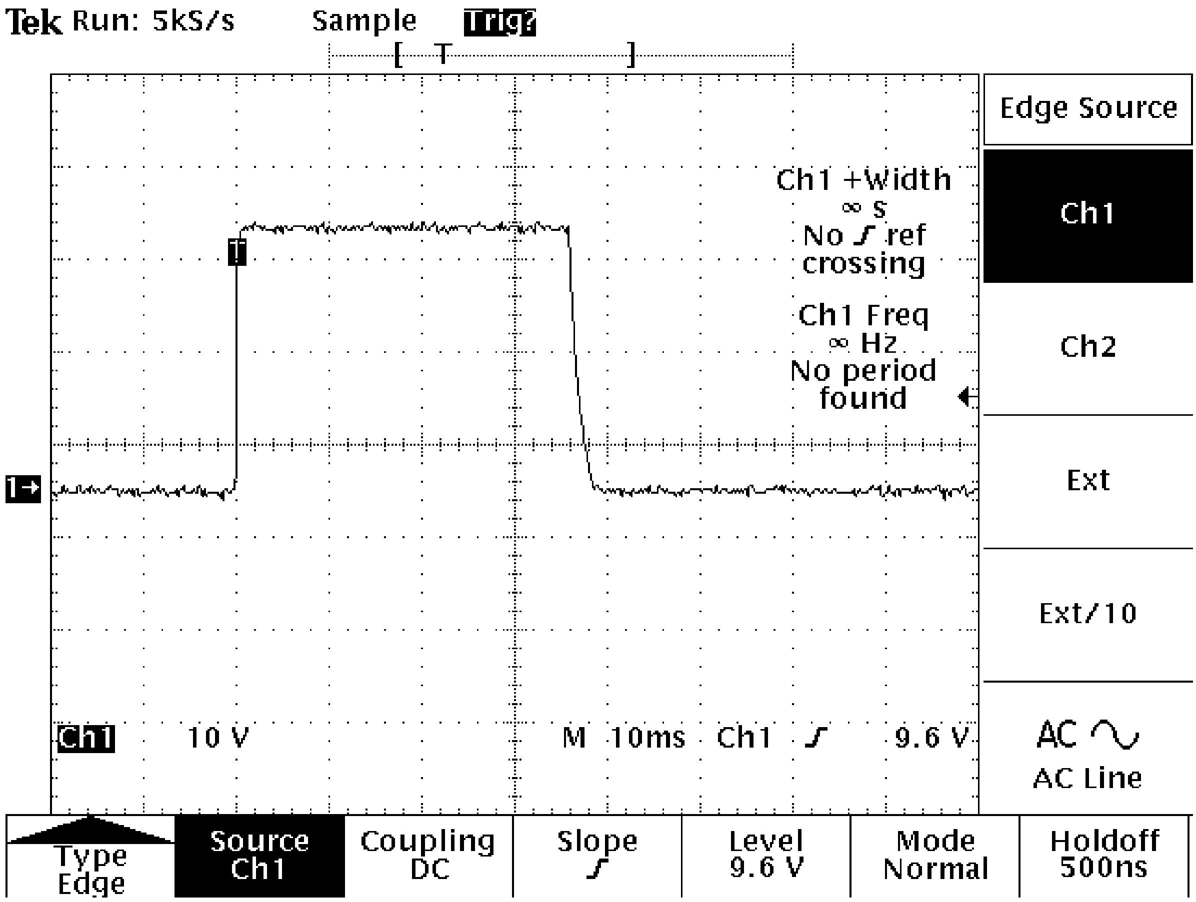
Since the antiskid control unit is installed on shelf N°1 of the avionics rack behind the cockpit, it suffered some fire damage and the box case was distorted by impact. The technicians were able to open the box cover by cutting in and peeling back the two planes so that the chassis could slide out. All the printed circuit boards on the chassis were undamaged and the unit could be tested satisfactory according to the manufacturers specifications.

The speed sensors of the four wheels were tested and all passed the manufacturers specifications.

The four wheel speed discrete relays were tested separately in the modes FLT and GND in order to verify their power up behaviour. In mode FLT, the duration of the power up signal was found to be in the range from 13 ms to 20 ms for the four relays. In mode GND, the signal duration was slightly less in the range from 11 ms to 19ms. All signals looked identical, only the duration varied and repeated tests produced always the same results. The following illustration shows the signal from the right hand outboard relay.



In order to reproduce the aircraft installation, where two relays are connected in series for the left and right hand gear legs, the test set up was reconfigured to demonstrate the power up behaviour, this time only in mode FLT, this being the situation of the aircraft. The duration of the power up signal was found to be 36 ms for both the right and the left hand side. The signal from the RH side being illustrated below. All signals looked identical and repeated tests produced always the same results.



Those were the characteristics of the installation associated with the antiskid control unit, part number 6004125 as installed on the accident aircraft.

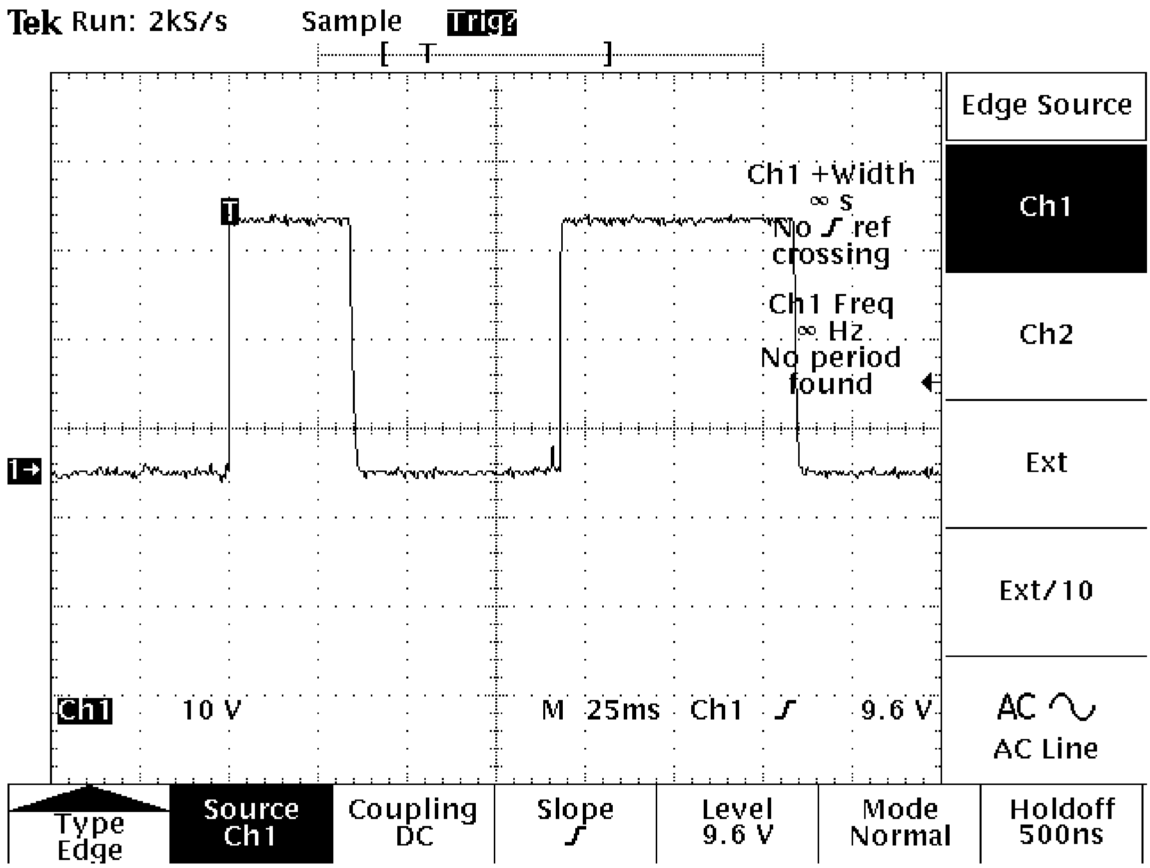
Modifications to the antiskid control unit published in Aug 1992 through Service Bulletin N° Fo50-32-4 issued by ABSC, changed the unit part number to 6004125-1, once the modifications had been performed.

In June 1994, a revision N°1 of Service Bulletin N° Fo50-32-4, was issued. The recommended modifications were still the same and revision concerned only the reason of the service bulletin which was now indicated as preventing a condition during power up of the skid control box whereby a signal pulse is inadvertently sent to the ground control relay thus affecting the flight idle stop solenoids (secondary stop). The unit's part number remained 6004125-1.

After having completed the test of the aircraft's unmodified unit, a modified unit available at the factory underwent the same tests, which demonstrated that the power up signal pulse was totally suppressed.

Additional tests were however performed on the antiskid control unit in order to analyse the performance of the unit by inducing electromagnetic interferences (EMI).

An electrical signal was introduced on the TEST button of the antiskid control unit, thereby inducing an EMI signal on power up. These tests were executed in mode FLT. It became apparent that a new signal was produced repeatedly on power up, showing a duration of around 65 ms. The tests were performed on the unmodified and the modified control unit. The following picture illustrates the signal output of the left hand wheels for the unmodified control unit.



The result was that the first impulse (~35 ms) was due to the power up of the unit through the release of the main gear up-locks and the second impulse (~65 ms) was triggered by the EMI signal.

The same tests were carried out on the modified unit (modified by ABSC SB F50-32-4) and it became apparent that the first impulse due to the power up of the system was suppressed, leaving only the EMI induced impulse.

The question remained, if the duration of the first signal (~35 ms) would be long enough to energise the flight idle stop solenoids.

The duration of the second pulse (EMI) was long enough to energize the flight idle solenoid under all circumstances, thus removing the secondary stop. There was however no reason to suspect that this was a condition of the accident.

It was later demonstrated at Fokker Services V.V. (see 1.16.5.4.) that the duration of the first pulse, when both antiskid control box channels were powered at the same moment was long enough to energize the flight idle solenoids.

Finally, the same tests were performed on a new engineering prototype of the antiskid control unit. It is noteworthy that during these tests, the two pulses were totally suppressed by the built in modifications of this prototype.

1.16.5.3 Propellers

The propeller components and blades were sent to their manufacturer. Among those components were the PCU's (Propeller Control Unit), Feathering pumps, Brush packs and Beta tubes.

The two propeller assemblies were dismantled. All the observed damages are consistent with impact or post impact damage. Impact marks on various components, when realigned, gave equivalent impact blade angles of –17 degrees for the right hand propeller and +84 degrees for the left hand propeller, which equated to full reverse and feather angles respectively.

The propeller control units were examined and satisfactorily passed their specified functional tests. The small amounts of damage or distortion were consistent with impact and did not hamper their correct functioning.

1.16.5.3.1. Propeller Electronic Control (PEC)

These two control boxes (one per propeller) were shipped and tested by the manufacturer. There was extensive fire damage to the outside casings of both units. Parts of the aluminium casings had burned and melted away. The connectors were also damaged by the fire and it was not possible to test the functionality of the whole units.

The individual circuit boards of both units were however in remarkably good condition regarding the external fire damage of the units. Testing the individual circuit boards as such was however discarded, as there was heat damage observed in small adjacent areas on each on the boards that might bear a risk of corrupting the memory chips and /or changing their status. It was therefore decided to remove the memory chips and have their information secured.

Considering the fact that propeller electronic control is only effective with the power levers in the flight regime (above flight idle), that events of the flight started to go wrong when the power levers were below flight idle in the beta mode, that up to this moment the crew did not mention any equipment failure, it was concluded to terminate this particular component testing.

1.16.5.4. Various components tested by Fokker Services B.V.

Below mentioned components were shipped to Fokker Services for testing.

- LH GND/FLT switch - equipment N° W0892B; this switch provides the GND/FLT signal of the LH gear to the ground control relay. All functionality tests were satisfactory. The determination of the operating force produced a value that was slightly out of limits, however this should not have any effect on the operation of the ground flight switching.

- RH GND/FLT switch - equipment N° W0892B; this switch provides the GND/FLT signal of the RH gear to the ground control relay. All functionality tests were satisfactory. This switch had suffered from impact. The plunger of the ground switch was bent holding the switch in the in-flight position (pushed in position). To restore the normal operation of the switch, the switch was removed from its bracket and the sleeve surrounding the plunger was cut open on a length of one centimetre. After this the plunger could be moved. No abnormalities were noted.

- Relay - equipment N° K2046A; this is the LH GND/FLT relay which receives the GND/FLT signal. It is carried into the ground control relay. The resistance of some of the switch contacts of the relay were slightly high. However the measured values should not create any aircraft abnormalities.

- Relay - equipment N° K0260A; this is the RH GND/FLT relay which receives the GND/FLT signal. It is carried into the ground control relay. No abnormalities were noted during the tests.

- Relay - equipment N° K0887A; this is the ground control relay which receives the signal from the GND/FLT relays and from the four wheel speed discretes. These are carried into the flight idle solenoid relay. No abnormalities were noted during the tests.

- Relay - equipment N° K2999A; this is the flight idle solenoid relay that triggers both LH and RH flight idle stop solenoids. No abnormalities were noted during the tests.

- Resistors - equipment N° R3001A and R3002A; these resistors are tied in parallel to the flight idle solenoid relay, one per flight idle solenoid. No abnormalities were noted during the tests.

- LH Flight idle stop solenoid – equipment N° L2723A and its associated brackets, linkages and push-pull rods; this solenoid frees the movement of the flight idle lock lever on the LH engine, thus permitting the LH power lever to be moved into the Beta range. No abnormalities were noted during the tests.

- RH Flight idle stop solenoid – equipment N° L2723A and its associated brackets, linkages and push-pull rods; this solenoid frees the movement of the flight idle lock lever on the RH engine, thus permitting the RH power lever to be moved into the Beta range. The plunger of the solenoid was corroded. This may explain why the forces measured were out of tolerance. However, the higher forces did not prevent the flight idle solenoid to function on the accident flight.

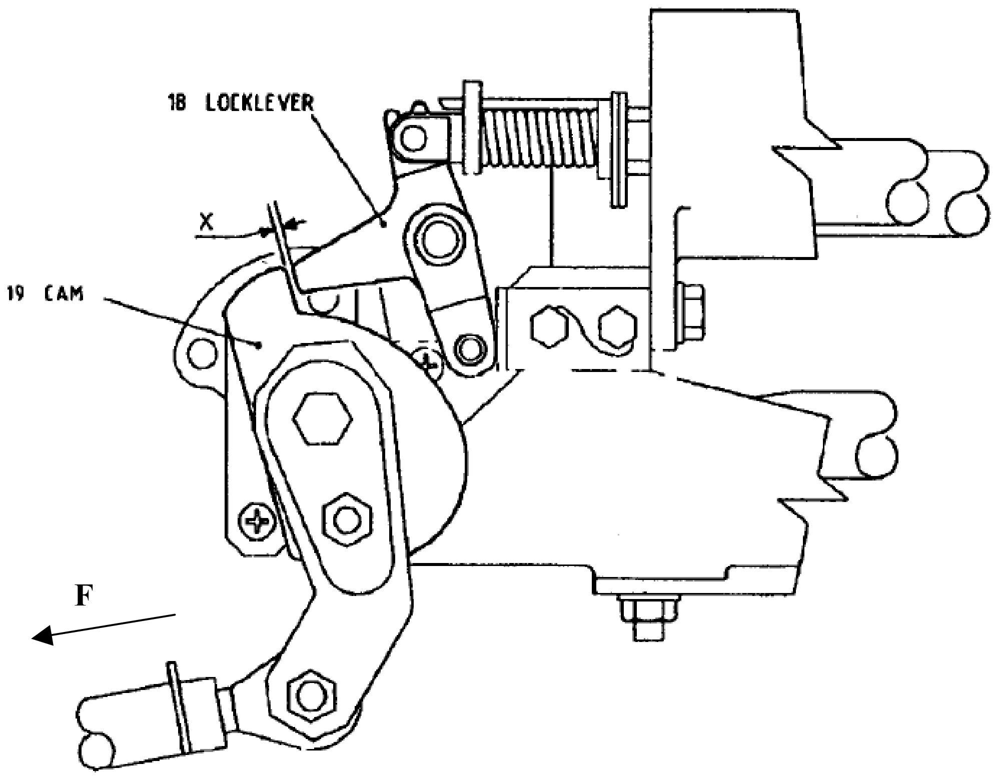
- Propeller Control Panel – equipment N° PL0011A; this panel provides switching and visual indications of the propeller electronic control systems and feathering pumps. No abnormalities were noted during the tests.

- Engine Control Panel – equipment N° PL0010A; this panel provides visual indications of engine and fuel system faults and performs switching operations relevant to engine starting and control. The background light of the lighting panel was inoperative. Beside this problem, the unit functioned properly.

- Engine Rating Panel – equipment N° AC1608A; on this panel, engine power selections are made i.e. for climb mode, cruise mode etc. The J2 connector was sheared off. However the panel could be normally tested. During the test, the lights of the switches worked intermittently. No other abnormalities were noted.

After these tests had been performed, an additional test was performed on relay - equipment N° K0887A in order to determine the minimum required pulse duration to activate the relay. Results were consistent with the relay data sheet that states that the relay must respond to a pulse duration of 20ms.

A final test was set up for the determination of the force required to prevent disengagement of the flight idle locklever and cam. (see illustration below)



When the flight idle cam is pulled against the flight idle lock lever and the flight idle solenoid is energised, than the amount of force applied, determines whether the flight idle lock can disengage.

With a force (F) applied to the push-pull rod was lower than 44.5 N, the flight idle stop disengaged when the flight idle solenoid was energised. When higher forces were applied the flight idle stop remained engaged. The same value was found on both flight idle solenoid assemblies. It was thus demonstrated, that by pulling hard enough back on the power levers against the secondary stop and with the solenoids energised, the flight idle lock lever was prevented from disengaging.

1.16.5.5. Pedestal and bulbs

The central pedestal and 192 light bulbs were removed from the wreckage and shipped to a French State approved laboratory for examination. Following results have been reached:

- Concerning the pedestal, no conclusions on lever position are possible. Functionally, no deficiencies have been found. All lever mechanisms including the ground range selectors working as specified. Electric continuity tests and the operation of the micro switches showed that these components were all in good operational condition,
- Concerning the analyses of the bulbs, the impact has not been hard enough to conclude on electrical circuits under tension at that moment.

1.16.6. Fokker 27 Mk050 simulator

Accompanied by Luxair pilots, the investigation team had a demonstration of the simulator actually used by the company in Maastricht. The aim was to reproduce the last minutes of the flight based on data recorded on the two flight recorders.

The simulator being configured to duplicate manoeuvres within the normal flight envelope, it has been demonstrated that it was not possible to reproduce the last minute of the flight, especially the conditions leading to the rapid descent.

Indeed, the data package did not include the flight conditions enabling the reproduction of selecting beta mode in flight.

1.16.7. Time synchronisation

Time stamped information gathered in ground based systems (radar and radiocommunications) and the aircraft recorders, although referring always to UTC, differ slightly as their individual time bases are independent. It is however possible to match the individual sequences as ATC communications are recorded on the ground and on the CVR of the aircraft. Comparing those two recordings, it has been established that the average time difference is about 2 seconds.

1.16.8. Power supply to the CVR and FDR

During normal operation, both generators supply electrical power through an electrical bus to both recorders. The generators go off-line when the propeller RPM (NP) drops below 50%, which was the case for the LH generator at time 09:05:23,2. With the LH generator off-line, only the RH generator provided the electrical supply to the recorders.

Time 09:05:26 is the last valid FDR recording and time 09:05:28 is the last valid recording of the CVR for the event sequence. However, at time 09:05:41 the CVR records a valid ATC message to another airplane meaning that at that moment the CVR was under power through its electrical bus.

1.17. ORGANISATIONAL AND MANAGEMENT INFORMATION

1.17.1. Luxair

Luxair was created in 1962 and started flights on a Fokker 27 from Luxembourg to Paris. Regular routes to the major European capitals and to the Mediterranean holiday destinations were added along the years.

The Airline Operator Certificate was valid on the date of the accident. Therein are listed, three Boeing 737/500, two Boeing 737/400, four Fokker 27 Mk050 and eight Embraer 145.

The JAR 145 maintenance approval was valid at the date of the accident.

Luxair received the JAR-FCL 1 TRTO approval from the Belgium CAA for the Type Training on Fokker F50, Boeing B737 300-800 and Embraer 145 on 09 April 2001. Prior to this JAR-FCL approval, no other approval procedure existed for training.

The Luxembourg civil aviation directorate approved the Training Manual, part D of the Luxair OPS Manual on 15 October 2001 (revision 9 concerning the whole manual)

Luxair received its first JAR-OPS Air Operator Certificate 18 February 1999. Prior to the JAR-OPS 1 regulation, Luxair operated under a Certificate of Competency according to ICAO Annex 6.

1.17.1.1. Pilot training

As Luxembourg is not issuing any professional licences and only validating foreign licences, no training program needed to be approved by the authority. However, two possibilities were detailed in a Luxair syllabus explaining how to become a Luxair pilot, namely:

1- either the candidate could follow an ab-initio training program through the Belgium Aviation School, or another selected school. Then the candidate had to pass a written examination, a psycho test, a medical test and a physical aptitude test before engaging an apprentice contract with the company. Then the candidate followed the training school to obtain his necessary licenses in order to conclude a working contract with Luxair.
2- or the candidate had already a CPL IFR with the theoretical ATPL. Before being selected, the candidate had to follow interviews, a psychological test and a practical test before being able to conclude a working contract with the company.

As both pilots were, prior to their employment with Luxair, in possession of a CPL associated with multi-engine and instrument ratings, they went through the standard Luxair conversion course to obtain a co-pilot type rating on Fokker 27 Mk050, associated with a CAT II qualification.

It is noteworthy that the selection file, as described above in point 2, for the co-pilot was available to the investigation commission. No such file concerning the captain could be obtained.

Nowadays, pilot training is done in accordance with the provisions and programs as detailed in their Operations Manual part D – Training manual. All theoretical courses are accomplished by Luxair ground instructors in their flight training centre in Luxembourg. Simulator trainings (Fokker 27 Mk050) are basically performed nowadays in Maastricht, by Luxair or approved flight instructors. This has not always been the case, as in the past simulator training has also been done with SAS in Stockholm. It is noteworthy that the captain's conversion simulator training has been done with MAS in Kuala Lumpur with local instructors, although based on the Luxair syllabus. A Luxair examiner and a CAA Examiner, if provided, take the simulator checks. In this case, the captain having a Swiss licence, a Swiss examiner took the check.

The co-pilot had his ground courses in Luxembourg and his simulator training in Maastricht.

1.17.1.2. Audits

Prior to the implementation of JAR-OPS, an audit conducted on 26 and 27 January 1998, by the authority was initiated in order to assess the compliance of the company's structure and documentation. Salient results of this audit were:

- Adaptations to the manuals needed to be done,
- Adaptations of the company structure to be made to the JAR-OPS requirements, namely the implementation of a quality assurance structure headed by a qualified post holder and the designation of an accountable manager.

Following their JAR-OPS approval, regular audits have been conducted.

1.17.1.3. Flight analysis

In November 2000, Luxair took the decision to equip the jet fleet (B737 and E145) with a flight analysis system. First tests on a B737-500 did not conclude on a viable system. In September 2002, two B737-400 and two E145 were equipped to start new test series in order to validate the hardware and the software of the system. This was finally achieved and in February 2003, it was decided to upgrade all the remaining jet aircraft with this system. Since August 2003, the flight analysis system is operational on their jet fleet.

1.17.2. Authority

1.17.2.1. JAR-OPS introduction

By grand-ducal regulation dated 23 March 1998, the JAA JAR-OPS 1 (adopted version from 22 May 1995) became applicable in Luxembourg.

1.17.2.2. JAR 145 Introduction

The JAR 145 was introduced into the Luxembourg system by EU regulation 3922/91, dated 16 December 1991.
Luxair received its first JAR-145 approval on 21 December 1993.

1.17.2.3. Licensing

Since Luxembourg does not issue yet any professional licenses, it refers to the method of rendering valid the foreign licenses by applying the recommendations of the ICAO Annex 1, and the grand-ducal regulation dated 17 August 1994 by applying the EU directive N°91/670/CEE, dated 16 December 1991 on the mutual recognition of personnel licenses between EU member States.

Presently Luxair employs a total of 154 pilots for the three types of aircraft that they operate. (51 on the B737, 70 on the EMB145 and 33 on the F50) Their professional licenses are spread over 9 different issuing countries.

1.17.2.4. Technical supervision

By ministerial decree dated 7 November 1952, the control for the issuance and revalidation of certificates of airworthiness of Luxembourg registered aircrafts, has been delegated to the French Bureau Veritas.

1.17.2.5. Operational supervision

By ministerial decree dated 24 January 1967, the same Bureau Veritas has been appointed to perform amongst other duties, the supervision of ground and flight operations for all international commercial air transport activities.

1.18. ADDITIONNAL INFORMATION

1.18.1. Previous occurrences

1.18.1.1. General considerations

The technical possibility to use reverse thrust (mode Beta) on propeller driven aircraft is a distinctive feature of all turboprop aircraft. An analyses of the accident records of propeller driven aircraft in general shows that some accidents occurred whilst the mode Beta was used in flight, despite the mechanical primary stop provided to avoid such a situation. It is documented that the pilot can easily remove this primary stop and select reverse thrust in flight.

Aircraft certification requirements stipulate that this mode Beta selection may only be possible by a positive, distinct and separate action by the pilot. The provided mechanical stop to be removed by the pilot satisfies this requirement. No certification requirements existed for the provision of a secondary stop on the Fokker 27 Mk050 aircraft.

Due to repeated incidents and accidents of this nature, many recommendations have been made to certification authorities, ranging from the installation of placards in the cockpit to the installation of automatic flight idle stops.

From the onset of the Fokker 27 Mk050 production, the aircraft was certified with a secondary flight idle stop, although this was not mandated by certification requirements..

1.18.1.2. Fokker 27 Mk050

Since the early days of the aircraft's line operation, the functioning of the antiskid control unit has been source for troubles. During aircraft maintenance, some operators discovered inadvertent activation of the flight idle solenoid due to the power up behavior of the antiskid control unit. Adding to the complexity of the system, the unit also provides signals for other aircraft systems, namely the propeller regulations through the automatic flight idle stop solenoids and thus, the problems surfaced also on the propeller regulation system.

In 1988 a report from an operator showed that the power lever settings below flight idle were possible in flight after reset of towing switch. This problem was identified during maintenance activities. The system was reviewed at Fokker Aircraft B.V. who confirmed the anomaly, which was caused by the power-up effect of the skid control unit. Fokker Aircraft B.V. determined that no immediate action was required in view of the low probability of the failure. This conclusion was reached because several conditions must be met simultaneously before any operational effect will appear. The conditions identified by Fokker Aircraft B.V. were

- Gear must be lowered,
- Main gear unlocking must be such that the inboard and outboard antiskid control channels which are powered by the LH and RH main landing gear uplock switches respectively must be powered within approximately 20 milliseconds from each other. Only if this condition occurs, the secondary lock is removed for 16 seconds.

- The power levers must be below the flight idle position (crew has to lift the ground range selectors). This is not a normal power lever position. Normally the approach is flown with approximately 15% to 18% torque (in GA power rating). The power levers are at such a torque setting above the flight idle position.
- The crew must continue to pull the power levers backwards within the 16 seconds time frame (after landing gear down).

In 1990, ABSC was requested by Fokker Aircraft B.V. to define a modification for the skid control unit to correct the power-up anomaly.

On 1 August 1992, the company Aircraft Breaking Systems Corp. (ABSC) issued service bulletin Fo50-32-4. A modification to the antiskid control box was introduced by adding one capacitor and one diode, one each per wheel board. This modification permitted that wheel speed sensor disconnect would be properly detected. The modifications being done, would change the unit's part number to 6004125-1.
This service bulletin was not mandated, but it was incorporated into the production as a standard from skid control unit serial AUG92-117 onwards.

In 1993, an incident report was received concerning power lever selection below flight idle during approach. Also verbal confirmation from several airlines was received, that ground range selector levers have been operated occasionally during flight, primarily in turbulence conditions.

On 29 June 1994, the company ABSC issued a revision N°1 of the service bulletin F50-32-4. It was a text modification of the service bulletin from 1992, saying that these added components prevent a condition during power up of the skid control box whereby a signal pulse is inadvertently sent to the ground control relay thus affecting the flight idle stop solenoids.
This service bulletin was not mandated, but the accomplishment of the service bulletin was recommended when the control unit would be removed or repaired for another reason. This however, is only done upon explicit request from the operator. Although the unit was returned a couple of times for repair, the operator never expressed such a request.

On 20 December 1994, Fokker Aircraft B.V. published a service letter N° 137 informing operators about the possibility of inadvertent release during flight of the mode beta locks. Fokker Aircraft B.V. identified there a working characteristic leading to a release of the flight idle stop.

In 1998, a complaint from an operator was received complaining about pulsating brake behaviour and loss of braking at low speeds in the normal braking mode.

On 2 August 1999, Fokker Services B.V. published a service bulletin F50-32-035 proposing a change of the grounding connections of the Anti-skid box. This change has been proposed because cases have been experienced of intermittent or no braking action from the normal braking system caused by EMI disturbance signals in the wiring from the wheel speed sensors to the antiskid box.
This service bulletin was not mandated.
Although the reasons for this Service Bulletin are not directly linked to the accident, it's application would have covered the application of ABSC service bulletin F50-32-4.

1.18.2. Operator's All Weather operations

The procedures for flight conduct are laid down in the Aircraft Operations Manual (AOM). Part A describing general basics and part B pertaining to the Fokker 27 Mk050 operation.

Most salient excerpts pertaining to the conduct of the accident flight are given below.

In AOM part A, it is stipulated in section 8.4.3 paragraph 100 "Commencement and continuation of the approach", that:

> *The captain or the pilot to whom conduct of the flight has been delegated may commence an instrument approach regardless of the reported RVR/visibility, but the approach shall not be continued beyond:*
> - *The outer marker or equivalent position for precision approaches*
> - *1000 ft above aerodrome level for non precision approaches*
>
> *if the reported RVR/visibility is less than the applicable minima.*

In the same section paragraph 200 " Applicability of aerodrome operating minima" it is stipulated that:

> *When RVR assessments are actually available, the TDZ RVR is the deciding value for all approaches, except circle to land approaches, which require a minimum meteorological visibility.*

In AOM part A, it is stipulated in section 8.4.4 under paragraph 100 "Definitions and principles" that:

> *As opposed to a conventional approach where either the captain or the co-pilot may perform an approach and land at the captain's discretion, in the monitored approach procedure, the aircraft is flown by the co-pilot (through the autopilot as applicable) down to the applicable MDA/DA/DH for all type of approaches followed by a straight-in manual landing.*
>
> *The landing, after the monitored approach, shall always be made by the captain.*

In the same section under paragraph 200 "Work distribution", it is stipulated that:

> *The co-pilot normally takes over controls at the top of descent, but at the latest when leaving the IAF or equivalent position when being radar vectored, till the captain announces << Landing>> and takes over the controls for landing.*

In AOM part B, it is stipulated in section 2.3.18 (Monitored Approach Procedure) under paragraph 100 "General Philosophy" that:

> *CAT II approaches are always flown using the monitored approach procedure. The autopilot is a requirement for CAT II approaches.*

Further more, it is marked in section 2.3.20 (Low visibility operations), under paragraph 100 "General" that:

The approach briefing is performed by the PF. However, before any low visibility approach, the Commander shall perform an operational review of the procedures, callouts and aircraft handling in case of missed approach.

In the same section under paragraph 300 “Task distribution for CAT II approaches”, it is stipulated that:

For CAT II (or monitored approaches in general), the F/O flies the aircraft through the autopilot and the captain lands the aircraft, if sufficient visual references are available at minima.

The whole section 2.3.20 (Low visibility operations) is shown as appendix 15 to this report.

1.18.3 AFM of the Fokker 27 Mk050

In the aircraft flight manual (AFM), section “Power plant limitations” paragraph –Propeller operating limitations- the following sentence is expressly marked in a warning message.

Do not attempt to select Ground Idle in flight. In case of failure of the flight idle stop, this would lead to loss of control from which recovery may not be possible.

A copy of this page is shown as appendix 19 to this report.

1.18.4. Traffic into the airport

Traffic flow at the time of the accident was representative for normal CAT II / III operations. Most of the regular commercial operators are qualified for CAT II and/or III operations. The normal VFR traffic from the flying clubs and flight schools did not exist.

During wintertime, the airport is available to traffic as of 05:00. 24 aircraft departed and 8 aircraft landed before the accident. A normal feature during CAT II / III operations is the substantial increase in separation minima between aircrafts inbound for landing with departing traffic adding to the delay in the arriving sequence. Within 9 minutes, 6 aircraft (the last one being the accident flight) had called Luxembourg approach for landing and two had been given approach clearances. Three others had been directed into the holding pattern at Diekirch, one of them waiting for a weather improvement. The accident flight, initially also directed into the same holding, was given an approach clearance about 10 NM before reaching the holding fix.

After the accident, the airport was closed due to non-availability of rescue services. With an additional flight having called Approach in the mean time, a total of 4 aircraft had to divert.

2. ANALYSIS

2.1. Accident scenario

The following scenario, based on CVR and FDR recordings and on technical facts, describes the crew's behaviour and actions when faced with events both inside and outside the cockpit, with a view to outlining the failures that occurred during the flight.

2.1.1. Descent

The CVR recording began at 8:33:49 when the aircraft was still in cruise. At 8:35:15 the crew checked for the first time Luxembourg ATIS. Subsequent remarks made by the copilot at that moment are first marks of the crew's future preoccupations. Indeed, as the RVR was below their minima, it appeared that there would be a delay resulting, either in waiting in the holding pattern, or a diversion. The copilot reactions, though banal, reflect a characteristic of the human behaviour which is often called "get home-itis", and which corresponds to a constant effort to perform actions and to take decisions which favour a single goal, namely in this case to be able to land timely at the desired place.

This phase did not last long and the crew were not that worried, as shown their personal discussions, since there was still some time before their arrival. So they continued the flight in a casual manner, initiating the descent at 8:41:08. At 8:44:46 the co-pilot listened again to the ATIS. The RVR had not changed from the previously announced 250 meters, the minimum value needed to start the final approach being 300 meters. At this time, the copilot showed his preoccupation by mentioning that the landing at their destination would not be guaranteed.

At 8:45:10 they started some discussions about various strategies that would give them a chance to land despite the bad weather conditions.

At 8:45:45 the co-pilot incited the captain to examine a CAT II approach procedure. The captain did not take up the issue, elaborating on RVR's that were anyway below 300 m. In fact, no decision about how to continue the flight was taken and consequently there was no approach briefing. Simultaneously, as there was little chance for an RVR improvement, the probability that they had to hold was high. This appeared in discussions they had about the RVR readings. Consequently they still had time to prepare for the approach.

At 8:46:21 started a long period, which lasted around 10 minutes during which the co-pilot was busy with the preparation of the public announcements to the passengers.

This episode highlights another aspect of crew cooperation and decision making process. Indeed the captain, without having discussed the issue previously, asked the co-pilot "have you already said something to the people?". The ensuing discussion among the crew revealed that the captain's request was based on the fact that he was the pilot flying and the co-pilot handling the radio communications. Having not discussed the issue, the co-pilot's surprise was real and he asked the captain, what to tell the passengers.

The captain's answer "I don't know" shows that there was still no action plan set. The instructions given later by the captain were not completely clear: he elaborated on some kind of "standby" announcement to the passengers, but did not indicate clearly whether they would wait in the holding pattern or not. The co-pilot was not comfortable with these vague indications and said: “what shall I tell the people, it’s always so difficult, it’s been a long time since I had this situation”. It was demanding for him to make this type of announcement (this will be confirmed later by his question to the cabin attendant "didn't I talk nonsense?"). This meant he was unavailable for other crew duties during those ten minutes.

In the mean time the captain called Luxair Dispatch to confirm the visibility and its evolution and to get some information about the take-off of a Cargolux flight.

At 8:52:49, the crew were instructed to enter the holding pattern at Diekirch DVOR.
Finally at 8:53:24, the co-pilot issued the passenger announcements in three languages, telling them that they will join the hold to wait for a weather improvement.

Shortly after this, the captain complained about the fact that he was not offered to land behind a heavy traffic on take-off.

Until then however, nothing had jeopardised the conduct of the flight, and it should be noted that it was a routine flight for a crew returning to its home base. At this stage, their plan of action was indeed to wait, as shown by the updating of the fuel available until they had to divert.

Two remarks can be made so far about the activity of the crew.

- It seemed that despite their desire to arrive, they were convinced that they would have to enter the hold, but they did not express it clearly and thus never shared a common objective. They remained rather isolated with different preoccupations, as it seemed inevitable that they would proceed to Diekirch and wait there until the visibility improved. Consequently, there was no pressure of time, they were about to enter the hold, so there still were opportunities to perform the approach briefing and to prepare for landing. Anyway, it was their only flight of the day.

- Both crewmembers were frustrated about having to wait. A lot of their resources were used to gather information and to imagine solutions to improve the situation. But this was more or less a waste of time and led them to abandon their standard operating procedures and use a more experimental but less efficient working method (the co-pilot was assigned an unusual task, the captain tried to find alternative but unrealistic solutions). The cockpit ambiance was characterised by a certain disorganisation, numerous interruptions to pick up meteorological information, the absence of briefings and checklist readouts.

At 08:58:50 ATC instructions, to descend to 3000 feet and to change their heading from 270° en route to Diekirch to 130°, puzzled the crew. Indeed, this was the first radar vector that would lead to the interception of the localiser. Their initial reaction was to check the RVR again with Luxair dispatch and at 09:01:06, the co-pilot said: “Yes, what are they going to do with us, holding or is it for an approach?”. Dispatch gave them 275 meters, confirmed by ATC a few seconds later, which was below their minima. However, the crew didn’t challenge the ATC clearance.

2.1.2. Intermediate approach

At 09:01:25, they were cleared for the approach as they were descending through an altitude of 6000 ft at a distance of thirteen NM from the airport. They then became preoccupied with the fact that they were going to land before all the aircraft in the holding as they began to prepare the aircraft for the approach. But as they were caught of their guard by the priority given to them, they did not have much time to do so. Their actions resemble to the initiation of a CAT II approach, but they never mention this. Finally their actions were not in line with Luxair standard operating procedures for this type of approach; for example, there was no transfer of the flying task to the co-pilot. They put the seatbelt sign on, set the altitude and were then interrupted by the capture of the localizer and the transfer to the control tower. This meant they did not have time to perform all of the approach actions and briefing, and more importantly that they did not have a common plan of action. Indeed, they were still confused by the RVR value and were not sure how they would handle the situation.

At 09:02:12, the captain told his co-pilot: "Tell him (*the control tower*) as a matter of fairness, that if we don't have 300 meters at Echo (*ELU beacon*), we are going to perform a go-around". This message was never delivered to ATC. The priority given to the flight in the approach sequence and the lack of the required RVR reading put some additional pressure upon the crew although, according to their procedures they could continue up to ELU.

At 09:02:57, aerodrome control confirmed an RVR reading of 250 m, which was in fact a worsening tendency compared to previous readings, prompting the captain to tell his co-pilot "Say we continue until ELU and if we have nothing, then ehhh", and the co-pilot's message to ATC was: "we keep you advised we're proceeding to ELU now and …er standing by, nine six four two". This did not correspond to what the captain initially said. The modification in captain's instructions confirms the lack of preparedness and show how the crew's determination had drifted. At that moment, the crew's attention was still focused on RVR improvement. It explains why nothing happened until they almost reached ELU. In fact, the beacon frequency was not dialled in, most probably because they did not have the time to reorganise the radio navigation means, which was the subject of a remark made by the co-pilot "you have to select a beacon". The Captain replied that the DME distance could replace the beacon. The crewmembers made a joke about this, which shows that there was nevertheless a relaxed atmosphere in the cockpit. It happened approximately thirty seconds before they flew over ELU, that is to say at around 1.3 NM from it.

At 09:04:30, about six seconds before ELU, the co-pilot started the BEFORE APPROACH checklist. This indicates very precisely what his mental picture was at that time; although they had not obtained a correct RVR, he was preparing for the final approach.

He was performing this checklist when they flew over ELU without announcing it. The captain decided to perform the go-around as planned before, ten seconds after passing ELU. The co-pilot did not react and continued with the checklist, placing the ground idle stop in the OFF position, this being the last action of this checklist. This misunderstanding most probably resulted from the lack of preparation and of accuracy resulting from the previous flight phase. Moreover, as the crew never got prepared for a go-around and as the aircraft was not in descent, this go around decision did not imply any significant action. The captain just maintained the aircraft in level flight at 3000 ft, as it had been before, without modifying the speed.

At 09:04:57, ten seconds after the captain said that they would perform a "missed approach", the controller transmitted the latest RVR, which was 300 meters. The aircraft was still flying in VMC above the fog layer.

2.1.3. Final approach, attempt to capture the glide path

This RVR value, which corresponded exactly to the required landing minima, triggered a sudden reversal of the captain's decision, who then obviously chose to resume the approach without announcing it. This was abnormal, since no procedure exists to capture the glide slope from above after having passed the final approach point. The captain, without saying anything, brought the power levers to flight idle and at the same time pulled the ground range selectors in order to be able to bring the power levers slightly further backwards into a position that corresponds to a setting below flight idle. This information is confirmed by the value of the Left and Right HP turbine RPM parameters, which were below the flight idle minimum and by the identified relevant noises on the CVR. This action was prohibited in flight. Since there was the secondary stop provided by the solenoids on the engines, the pilot would feel a hard stop of the power levers (see paragraph 1.16.5.1.)

In reality, there were two goals to achieve, each one being contradictory with the other. Indeed, when the captain decided, to catch up with the glide, the aircraft was 300 ft above it. Due to the growing lack of time and lack of preparation since they had been cleared for the approach, the crew did not have time to slow the aircraft down and configure it for landing. Catching up with the glide from above, meant descending rapidly and consequently increasing the speed, which was still relatively high. So the captain used a personal solution to resolve this contradiction. Using a propeller pitch selection below flight idle would decrease the power and could help to descend without increasing the speed. The investigation has shown that it actually did not improve the rate of deceleration. Considering that the captain reduced power and entered the beta range in the same movement indicates that it was a deliberate action.

At 09:05:02, the co-pilot stated, “will not be enough/sufficient” which could mean that despite this action of the captain, he doubted the obtained sink rate would be sufficient to capture the glide path.

At 09:05:05, the co-pilot informed the controller that they were continuing the approach. The crew had been deviating so much from standard operating procedures that a certain confusion prevailed in the cockpit.

It is remarkable to note that, although the captain decided to continue the approach, he did not call for the BEFORE LANDING checklist. Requiring a significant sink rate to capture the glide path from above, the captain did not require flaps and gear to be selected, which are the first two items of this checklist. He waited several seconds before putting the aircraft into descend, the autopilot being still engaged. However, it is noteworthy that the co-pilot tried to help by proposing the extension of the flaps, then the landing gear.

At 09:05:12, the aircraft was finally established in descent, still well above the glide slope.

Finally it has to be pointed out that the passengers were never informed about the imminent landing.

2.1.4. From landing gear extension until the impact

The investigation has demonstrated that the most probable cause for the removal of the secondary stop, was the extension of the landing gear at 09:05:16, which triggered the energising of the flight idle stop solenoid relay through the antiskid box. Since these stops were no longer effective, the power levers were free to be moved further back into the beta mode range.

The captain, faced now with a sudden time pressure, may not have felt the absence of the secondary stop and with the hand pressure applied to the power levers he may have unintentionally passed through the ground idle position (a double click on the CVR can be attributed to this event), towards full reverse.

Following events happened in a very rapid sequence. The increase in reverse power triggered a propeller overspeed that was heard and noticed by the crew. Feeling a tremendous increase in drag and the consequent deceleration, one of the crewmembers retracted the flaps. The crew moved the power levers forward into the flight range (see 1.16.4.), then shut down the LH engine and a couple of seconds later the RH engine by putting the fuel levers in the SHUT position.

Some elements noticed during the wreckage examination allow to assume that the crew might have attempted to restart the engines, but as the FDR and CVR readings stopped at this moment, was is not possible to further analyse the subsequent flight phase.

The descending aircraft entered the fog, and the crew did what they could to flare the aircraft at the last moment when they saw the ground.

2.2 Crew performance – Operational failures

In the preceding scenario, numerous operational deficiencies were highlighted.

2.2.1 Deviations from standard operating procedures

- No approach preparation and briefing, meaning that the crew did not express which kind of approach will be performed:
- No observance of CAT II requirements

2.2.2 Violations of rules and regulations

Initially, the captain elaborated several strategies that would permit to get around the problem of the RVR situation. At a certain moment he said, “Dad still works with all the tricks”. It is possible that this state of mind led him to subsequent actions, namely:

- Interception of glide slope from above.
- Selection of the power levers below flight idle in flight.

2.2.3. Lack of cooperation between crew members

- Non-standard task sharing; confusion on passenger announcement, transfer of flying tasks to the co-pilot in CAT II not performed:
- Captain did radio communications with dispatch at several occasions
- Co-pilot not complying with captain requests and instructions (“tell him that if we don’t have 300 meters at Echo we are going to perform a go-around” was not transmitted to ATC, the go-around announcement was ignored by the co-pilot).
- The captain did not announce his intentions to continue for landing.
- Flaps and gear extended upon co-pilot suggestions and not commanded by the captain.

All the abovementioned events testify the absence of method and professionalism of the crew in handling a normal situation. The combination of routine and “get home itis” favoured the decision of the crew to accept the approach clearance, although they were not prepared to it. At this precise point the chain of events started to build up which ultimately led to successive uncoordinated decisions and actions by the crewmembers.

2.3. Training

The situation outlined below applied to the period before JAR-OPS was implemented (July 1999). Both pilots received their training within Luxair during this period.

Pilots from Luxair detain licenses from nine different countries. Their initial training, type training, conversion training may be made in different training centres located in various countries, depending upon availability of the training centres or other factors.

The training programs had not been submitted for approval to the authority, as there was no requirement to do so.

These varieties of trainings do not favour standardized working procedures and methods. It may contribute to the abovementioned deficiencies regarding crew cooperation.

2.4. Organisational aspects and oversight

It became obvious during the investigation that the existing control mechanisms including the recurrent trainings, did not prevent the crew to diverge dramatically from standard procedures. It was also discovered that, about an hour before the accident, another F27 Mk050 from Luxair landed without having at any moment received a RVR reading at or above their required minima of 300 meters.

Noted deficiencies of the accident crew, as well as the landing of the other Luxair F27 Mk050, indicate that the methods in place to guarantee safe operations are not sufficient.

2.5. Beta range safety devices

2.5.1. Secondary stop design

The secondary stop was introduced on turboprops to prevent the selection of beta mode in flight. Accident statistical data on turboprops document that, the intentional use of beta mode in flight is sometimes used by pilots to dissipate excessive energy.

The device installed on the F27 Mk050 aircraft was changed in 1988 from a single solenoid installed on the central pedestal, to two separate solenoids installed on each engine. It must be noted that the secondary stop design allows the pilots to lift the ground range selectors (also in flight) and move the power levers through the primary flight idle stop.

This design does not prevent the intentional or unintentional removal of the primary stop by the pilot, meaning that the safety function of the first device is not guaranteed. The primary and the secondary stop system of the Fokker 27 Mk050 was certified against JAR25.1155 (change 9). It is worth mentioning that the new version of European airworthiness requirement JAR25.1155 (harmonization initiative set up by the FAA and JAA) issued in May 2003 (change 16), introduces this notion of "a means to prevent both inadvertent or intentional selection or activation of propeller pitch setting below the flight regime". Excerpts of this new regulation is shown in appendix 21.

2.5.2. Secondary stop reliability

By Fokker Aircraft B.V. Service Letter n°137 issued in 1994, the operators were informed about the possible scenarios leading to the deactivation of the secondary stop. Fokker Aircraft B.V. required no corrective action because they considered this occurrence was remote (see paragraph 1.18.1.2); however Fokker Aircraft B.V. indicated in the same letter that it could happen during each flight when the landing gear is selected down. These two statements seem to be non coherent and some questions remain regarding the reliability of the system.

The aim of the secondary device is to be an ultimate backup to avoid a catastrophic situation. The philosophy of this concept implies that the backup must be reliable. Despite the presence of two different safety devices serving one single purpose, their intended design purpose is not fulfilled. The new JAR25.1155 (change 16) requirements also introduces "a reliability such as the loss of the safety devices is remote".

2.5.3. History of the system

Fokker Aircraft B.V. identified the potential deactivation of the secondary stop as of 1988. A solution was proposed by a modification of the anti skid box through a Service Bulletin in 1992. A complete explanation of the failure was distributed to the operators maintenance departments in December 1994 by the Service Letter n°137, dated 20 December 1994. Luxair received this service letter early by fax on 13 December 1994.

Two remarks can be made about this: as it was a technical note containing also some operational information, Luxair maintenance department received it. It could be established that this Service Letter had reached the operations department. However, it could not exactly be determined at what date. No indications could be obtained that the information contained in this document was at that time incorporated into the operational documentation, which may have contributed to this important information being lost over time.

3. CONCLUSIONS

3.1 Findings

1. The crew possessed the necessary licences and qualifications to perform the flight,

2. The aircraft possessed a valid Certificate of airworthiness,

3. The Luxembourg authority has not approved the aircraft flight manual, originally approved by the Dutch authority.

4. The aircraft weight and balance were in the approved range.

5. There were no aircraft system malfunctions until the final descent,

6. Radio navigation aids functioned normally

7. RVR was below approved company minima during the initial and the intermediate approach,

8. During the approach, the crew did not comply with the operator’s procedures,

9. Despite the fact that the meteorological conditions for a CAT II approach prevailed, none of the required prerequisites, to perform a CAT II approach, were taken by the crew.

10. The captain resumed the final approach after having announced a go-around, without co-pilot’s reaction,

11. In order to achieve this goal, the crew performed several non-standard actions, amongst which the prohibited positioning of the power levers beyond flight idle. The AFM contained a limitation that prohibits the selection of ground idle in flight.

12. The selection of the landing gear down, triggered the deactivation of the second safety device (solenoid secondary stops) which was a possible malfunction identified by the manufacturer.

13. The aircraft’s drag increased significantly and the aircraft’s speed dropped as the rate of descent increased,

14. Both engines were shut down via the fuel levers,

15. After engine shut downs, the two flight recorders stopped recording,

3.2 Causes

The initial cause of the accident was the acceptance by the crew of the approach clearance although they were not prepared to it, namely the absence of preparation of a go-around. It led the crew to perform a series of improvised actions that ended in the prohibited override of the primary stop on the power levers.

Contributory factors can be listed as follows:

1. A lack of preparation for the landing, initiated by unnecessary occupations resulting from an obtained RVR value, which was below their company approved minima, created a disorganisation in the cockpit, leading to uncoordinated actions by each crewmember.

2. All applicable procedures as laid down in the operations manual were violated at some stage of the approach. All this did not directly cause the accident, but created an environment whereby privately designed actions were initiated to make a landing possible.

3. Routine and the will to arrive at its destination may have put the crew in a psychological state of mind, which could be the origin of the deviations from standard procedures as noticed.

4. The low reliability of the installed secondary stop safety device that was favoured by the non-application of service bulletin ABSC SB F050-32-4. Also the mode of distribution of the safety information (Fokker Aircraft B.V. – Service letter137) to the operator as well as the operator's internal distribution to the crews, that did not guarantee that the crews were aware of the potential loss of secondary stop on propeller pitch control.

5. The lack of harmony resulting from the use of various training centres and non-standardised programs that might have impaired the synergy of the crew.

4. SAFETY RECOMMENDATIONS

4.1. Safety measures taken since the accident

On 14 November 2002, technical services from Fokker Services B.V. issued an All Operators Message (ref. AOF 50.022) to recall, amongst other, to all operators of Fokker 27 Mk050 aircraft, the characteristics of the security systems of the propellers.

The investigation commission issued following recommendations:

- The first, safety recommendation N°1, dated 15 November 2002, stipulating that:

  In order to avoid the failure of the Flight Idle Stop security, the Investigation Commission recommends that the opportunity should be evaluated to render the modification of the Antiskid Control Box stated in the Service Bulletin be mandatory for all Fokker 50 aircraft.

  Furthermore and without waiting for this modification, the Investigation Commission recommends that the crewmembers should be informed about the potential functioning of the system as mentioned above and about the content of Fokker message to all operators AOF50.022 dated 14 November 2002.

- The second, dated 28 November 2002, recommends the publication of an airworthiness directive stipulating that:
  - Service bulletin N° Fo50-32-4-revision 1 from ABSC and
  - Service bulletin N° F50-32-035 from Fokker Services B.V.,

  be made mandatory for all Luxembourg registered Fokker 50 aircraft.

  This airworthiness directive LUX-2002-001 has been published on 29 November 2002.

  Informed in parallel about this recommendation, Luxair has proceeded with the modifications of their aircraft between 15 November and 8 December.

- The third, safety recommendation N°2, dated 23 January 2003, stipulating that:

  In order to improve the functioning of the secondary safety Flight Idle Stop, the investigation commission recommends, that the announced publication of Service Bulletin Fo50-32-7 be speeded up and that its application be made mandatory for all Fokker F27Mk050 type aircraft.

On 8 May 2003, technical services from Fokker Services B.V. issued an All Operators Message (ref. AOF 50.028) announcing the publication of:

1. Fokker SB F50-32-038
2. ABSC SB Fo50-6004125-32-01

and stipulated that, with these modifications incorporated, abnormal braking, loss of braking at low speeds as well as unintended energizing of the flight idle stop solenoids are considered to be adequately covered.

On 8 May 2003, technical services from Fokker Services B.V. issued a Manual Change Notification / Maintenance Documentation (ref. MCNM-F50-045) incorporating the modifications to perform on the Skid Control Unit.

On 9 May 2003, a fourth safety recommendation was made, recommending the publication of an airworthiness directive stipulating that:

- Service bulletin N° Fo50-6004125-32-01 from ABSC and
- Service bulletin N° F50-32-038 from Fokker Services B.V.,

be made mandatory for all Luxembourg registered Fokker 27 Mk050 aircraft.
This airworthiness directive LUX-2003-001 was published on 12 May 2003 and all aircraft need to be modified by 1 November 2003.

On 31 May 2003, the Dutch authorities issued an airworthiness directive BLA Nr 2003-091, rendering service bulletin N° F50-32-038 from Fokker Services B.V. mandatory.

By 9 August 2003, all Luxembourg registered Fokker 27 Mk050 aircraft had been modified accordingly.

4.2. Improvements in the design of the safety device

Not withstanding the existing recommendations and procedures, it appears that intentional override of the primary flight idle stop on turboprops in flight is not excluded.

The existing design of the Fokker 27 Mk050 does not prevent the selection in flight of the propeller pitch setting below the flight idle regime.

Hence it is recommended to review the existing design in order to examine the possibility of prohibiting in flight, intentional and inadvertent selection of the propeller setting below the flight idle regime.

It is further recommended, considering the number of similar accidents on turboprops in general, that authorities responsible for airworthiness of these types of aircraft, check whether the design of these safety devices as proposed by JAR25-1155 (change 16) should be made applicable to existing designs.

4.3. Organisation and management

4.3.1 Luxair

4.3.1.1. The investigation of the accident brought to light deficiencies in the domain of crew task-sharing. Consequently it is recommended:

- that a review of the airline operational oversight be performed.

4.3.1.2. The investigation pointed out that the variety of training centres used by Luxair could have had an influence on crew cooperation and synergy. It is hence recommended:

- to ensure that recruitment procedures, pilot training, strengthen cockpit resource management (CRM) training and recurrent trainings allow to reach a standard of harmonization.

4.3.1.3. Considering the importance of the information contained in different technical publications issued by a manufacturer and concerning flight operational safety matters as well, it is recommended:

- that Luxair makes sure that their organisation ascertains the diffusion of this type of information to all parties concerned.

4.3.1.4. ICAO Annex 6 recommends, *" that from 1 January 2002, operators of aircraft whose takeoff weight exceeds 20,000 kg establish and maintain a flight data analysis programme in the context of their accident prevention and flight safety programme"*.

This system enables the operator to constantly monitor the operations and to identify the deviations. Such a system is in place in Luxair for the E145, B734 and B735 types of aircrafts. Hence it is recommended:

- that such a system be implemented also for the Fokker 27 Mk050 type of aircraft.

4.3.2. Authority

4.3.2.1. The investigation of the accident brought to light deficiencies in the domain of crew task-sharing. Consequently it is recommended,

- that the authority reviews its methods of oversight of the airline.

4.3.2.2. The variety of training facilities that have been used by Luxair could have had an influence on the lack of application of standard methods that were pointed out in the scenario of the accident. As before the application of JAR-OPS1, there was no formal follow-up nor oversight of the different trainings and in the light of the accident it is today difficult to evaluate the situation at Luxair regarding this standardization. Furthermore, the oversight of these trainings did not allow to highlight its potential weaknesses. It is therefore recommended that the authority,

- perform a review of the previous trainings in order to establish the measures to put in place to achieve a suitable harmonization;
- review the methods for approval and oversight that would improve the detection of deviations during the training.
- that the authority ensures that the training environment of the operator is kept as stable and harmonized as possible.

This page intentionally left blank